"MUTATION STUDIES IN CONFECTIONARY TYPE OF SUNFLOWER (*Helianthus annuus* L.)"

By

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B.Sc. (Agri.)

MASTER OF SCIENCE
(Agriculture)
IN
AGRICULTURAL BOTANY
(GENETICS AND PLANT BREEDING)

DEPARTMENT OF AGRICULTURAL BOTANY
COLLEGE OF AGRICULTURE, LATUR

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PARBHANI- 431402, MAHARASHTRA, INDIA

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DISSERTATION

Submitted to
The Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani
In partial fulfillment of the requirements
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PARBHANI- 431402, MAHARASHTRA, INDIA

2018

CANDIDATE'S DECLARATION

I hereby declare that this dissertation

or part thereof, has not been

Previously submitted by me

for a degree of any

University or

Institute

Place: Latur (**K. SAI PHANINDRA**)

Date: / /2018 **(Reg. No. 2016A/32ML)**

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CERTIFICTE - I

This is to certify that the thesis entitled **"Mutation studies in confectionary type of sunflower (*Helianthus annuus* L.)"** submitted by **Koppuravuri Sai Phanindra (Reg.No: 2016A/32ML)** to the Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani in partial fulfillment of the requirements for the degree of **Master of Science (Agriculture)** in the subject of **Agricultural Botany (Genetics and Plant Breeding)** is record of bonafide research work carried out by him under my guidance and supervision and the thesis has not previously formed the basis for the award of any degree, diploma or other similar title.

Place: Latur **(V. N. Toprope)**
Date : / / 2018 Research Guide

CERTIFICATE – II

This is to certify that the thesis entitled **"Mutation studies in confectionary type of sunflower (*Helianthus annuus* L.)"** submitted by **Koppuravuri Sai Phanindra (Reg.No: 2016A/32ML)** to the Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani in partial fulfillment of the requirements for the degree of **Master of Science (Agriculture)** in the subject of **Agricultural Botany (Genetics and Plant Breeding)** has been approved by the student's advisory committee after *viva-voce* examination in collaboration with the external examiner.

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Place : Latur

Date : / / 2018 *K. Sai Phanindra*

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LIST OF ABBREVIATIONS

Sr. No.	SYMBOLS	ABBREVIATIONS
1.	%	Per cent
2.	*	Significant at 5 % level
3.	**	Significant at 1 % level
4.	ORS	Oilseeds Research Station
5.	$\bar{X}$	Mean value
6.	CV	Coefficient of variation
7.	CD	Critical difference
8.	SE	Standard error
9.	cm	Centimeter
10.	d.f	Degrees of freedom
11.	EMS	Ethyl methane sulphonate
12.	SA	Sodium azide
13.	ppm	Parts per million
14.	mM	Millimolar
15.	ml	milliliter
16.	g	Gram
17.	GCV	Genotypic coefficient of variation
18.	PCV	Phenotypic coefficient of variation
19.	ECV	Environment coefficient of variation
20.	H^2	Heritability
21.	H^2 (b)	Heritability (Broad sense)
22.	GAM	Genetic advance as per cent of mean
23.	*i.e.,*	That is
24.	Var	Variety
25.	*Viz.,*	Namely
26.	No.	Number
27.	*et al.,*	and other co-workers
28.	Fig.	Figure
29.	MSS	Mean sum of Squares

INTRODUCTION

CHAPTER I

INTRODUCTION

Sunflower (*Helianthus annuus* L. 2n=34) is a native of southern USA and Mexico, belongs to family 'Asteraceae' which includes 20 genera with 67 species. It is an important oilseeds crop among the four major oilseeds crop cultivated in the world *viz.,* soybean, brassica, sunflower and groundnut. The cultivated sunflower is stated as "Golden Girl of American Agriculture" (Girishraj *et al*., 2013). It is one of the useful contingent crops especially under rainfed cultivation owing to its day neutral nature and tolerance to temperature and soil moisture regimes (Natikar *et al*., 2013).

Sunflower is rich source of edible oil (40-52%) and it is good for heart patients due to presence of PUFA *i.e.,* Linoleic acid (55 to 60%) and oleic acid (25 to 30%). In addition to B and E vitamins, the sunflower seeds are excellent source of various minerals *i.e.,* copper, manganese, magnesium, phosphorous.

Two types of sunflower are grown *viz.,* oil seed purpose and non oil seed sunflower for commercial market. Non-oilseed sunflower is known as confectionery sunflower, and is usually white striped and/or comes in large-seeded varieties. They generally have a relatively thick hull that remains loosely attached to the kernel, permitting more complete dehulling. Seed of the non-oil seed hybrids generally is larger than that of the oilseed types and has a lower oil percentage with high protein content and sugar content. The kernels of confectionary type also used in bakery products in european countries. USA leads in production of confectionary sunflower followed by argentina. The varieties cultivated for confectionary purpose are known as *Helianthus annuus macrocarpus* L.

The nutritional composition of confectionary sunflower constitutes 900g/kg of dry matter, 235g/kg of dry protein, 760g/kg of total

digestible nutrients, 250g/kg of oil, 241g/kg of crude fibre, 38g/kg of ash, 3g/kg of calcium and 6g/kg of phosphorous (Girishraj *et al.*, 2013).

The main aim of confectionary sunflower breeding is to develop lines with low hull content, high oil content, high yielding ability, high sugar protein content and self fertile lines. Presence of genetic variability in any crop is initial step for further improvement by providing choices to the breeders for development of varieties and hybrids with high global standards. The success of any crop improvement programme in meeting the various objectives is dependent upon availability of necessary genetic variation and to produce with latest technologies present in global era.

Mutation, spontaneous or induced, is an important source for creating genetic variability. Mutations are the tools being used to study the nature and function of genes, there by producing raw materials for genetic improvement of economic crops (Adamu and Aliyu, 2007). Mutation breeding has been used to develop many cultivars with more economic importance (Beckstrom-Sterberg *et al.*, 1994). Mutation breeding helps to improve the well adapted variety by modifying one or more traits for crop improvement purpose. A desired mutation can be recovered in a homozygous stage already in the M_4 or M_5 generation as compared with the F_6 or F_7 generation in the case of conventional breeding methods. Chemical mutagens were more efficient than physical ones in inducing viable and total number of mutations (Auti and Apparao, 2009).

By 2017 more than 3227 mutant varieties are created by mutation in different crops on global basis. In India, so far 335 mutant varieties are released by induced mutagenesis. China occupied top position in release of mutant varieties followed by Japan and India.

Chemical mutagens like ethyl-nitroso-urea, methyl-nitroso-urea, ethyl-methane-sulphonate (EMS), sodium azide (NaN_3), 5-bromo uracil, 2-amino purine and physical mutagens like X-rays, gamma rays, UV rays are mostly used for mutation induction in plants. Among all these sodium azide

(NaN_3) is considered as safe and it creates point mutations in the genome of plants through metabolite and thus produced protein in mutant plants has different function compared to the normal plants (Khan and Goyal, 2009). The effect of chemical mutagens depends on the permeability of seed coat, concentration of mutagen, period of soaking in mutagen and nature of the mutagens. Sodium azide (NaN_3) widely used in various crops to improve their yield, quality traits and creates resistance to them against harmful pathogens (Al-Qurainy and Khan, 2009). It is used to create durability in different susceptible crops to improve their yield and quality characters in opposition to damaging pathogens (Adamu and Aliyu, 2007).

Hence, a systematic study on the nature, magnitude and breeding value of the genetic variability generated through induced mutagenesis in the confectionary sunflower genotypes, EC 625693, EC 318761 and SCG 62 for hull content, sugar content and other yield contributing traits is essential.

Therefore, the present investigation, entitled "Mutation studies in confectionary type of sunflower (*Helianthus annuus* L.)" was undertaken with following objectives.

1. To study extent of genetic variability for yield and yield contributing characters.
2. To study Heritability and genetic advance for yield and yield contributing characters.

REVIEW OF LITERATURE

CHAPTER II

REVIEW OF LITERATURE

Sunflower (*Helianthus annuus* L.) is an important oilseed crop. Owing to high demand of confectionary sunflower, there is need to initiate the breeding work to identify genotypes with high sugar content, protein content, yielding ability and low hull content lines. The knowledge on genetic variability in any crop species plays an important role in framing a successful breeding programme. Mutation breeding has been successfully used in sunflower breeding to create genetic variability with altered plant characteristics. Therefore, the present investigation was undertaken in order to create variability through mutation breeding. Some of the important and relevant literatures pertaining to these aspects under the following heads are discussed here.

2.1 Morphological Mutants.

2.2 Variability.

2.3 Heritability and genetic advance.

2.1 Morphological Mutants.

Ahmed and Goud (1977) irradiated the sunflower genotype EC-69874 with gamma rays. Several macro-mutants were observed in M_2 generation of sunflower, of the many double headed mutants isolated, the one mutant had two heads of normal size (18 cm diameter) and bifurcated of the stem at tip. A few plants were isolated in M_2 generation, which were suspected to be apomictic in nature.

Jambhulkar (1999) irradiated sunflower variety, Surya with 4 doses of gamma rays. In the M_2 generation, 27 morphological mutants were isolated. Among them, 3 each were for chlorophyll and stem, 9 for leaf, 8 for capitulum and 4 for seed coat colour. Some of the mutants possessed more than one mutated character. Mutations like yellow leaf vein, fasciation, wrinkled leaf, zigzag stem, zigzag ray florets, stigma emergence and brown patch

mutants are novel characteristics. Among the 4 doses of gamma rays higher 200 Gy was the most effective dose for induction of mutation in sunflower.

Jambhulkar (2002) observed an extreme dwarf mutant in M_9 generation of diploid sunflower variety (surya) treated with gamma radiation. The significant attribute of the mutant was the drastic reduction in the plant height to 11.66 cm compared to 180 cm of the control. The dwarf mutant was slow growing. Head diameter (7.76 cm), length of leaf (10.72 cm), breadth of leaves (9.17 cm) and length of ray florets (2.18 cm) were reduced to approximately half compare to the control plant. The normal plants flowered in 47 days and matured in 97 days, whereas the dwarf mutant flowered in 123 days and matured in 172 days.

Lyakh *et al.* (2005) treated mature and immature seeds of self-pollinated sunflower lines, Z1-9, Z1-102 and Z1-169 were treated with different concentration of EMS @ 0.01%, 0.1 %, 0.5 % for 6 and 12 hours. Eighteen types of morphological mutations were found in M_2 generation as chlorophyll deficiencies (6), leaf (5), stem (4), ray floret shape and colour (4). Whitish mutant of chlorophyll deficiencies shows reduction in plant height and productivity. Dwarf plants of stem mutant group had short internodes with no formation of seeds. The largest mutations were obtained in Z1-9 and Z1-102 of mature seeds. The whitish mutation was isolated with highest frequency after mutagen treatment of mature seeds of the line, Z1-169 (EMS-2.44, 2.47, 5.66, 5.50, 2.0, 1.08 @ 6 hours). More viable chlorophyll mutations are viridis, xanthan with EMS @ 0.01-0.1 %. Dwarf mutants were isolated in Z1 9 of 6 and 12 hours at 0.5 %, 0.01 %. Most of the isolated mutants show reduction in plant height and productivity except viridis, xantha and ray floret colour mutants.

Soroka and Lyakh (2009) created genetic variability in immature sunflower embryos of Z1-809 and Z1-95 with EMS at 0.02% for 16 hours. The frequency and spectrum of morphological and physiological mutants obtained in M_2 and M_3 generation. Thirty three types of mutation were found and

classified as chlorophyll deficiency (3), cotyledon mutation (1), leaf mutations (6), stem mutations (9), inflorescence mutations (11), seed mutation (1) and physiological mutations (2). Differences were observed between genotypes for the spectrum and frequency of mutation.

Kumar and Ratnam (2010b) exposed the sunflower varieties, USH-430 and Nidhi-999 with gamma rays at 2, 4, 6, 8, 10kR and sodium azide at 2, 4, 6, 8, 10mM and also for both. Macro and micro morphological mutants were obtained in his research. Micro mutants were patchy albino, white margin, virescent, darker green, xantha purple, albino. The micro mutants were increased with increasing dose concentrations of all the three treatments in both varieties. The macro mutants include branched, basal stem bifurcation, rosette and compact leaf arrangement, double headed, dwarf early-I, dwarf early-II and mosaic leaf arrangement.

Mostafa (2011) studied the effect of NaN_3 on sunflower varieties of Giza 1 and Giza 102 with concentration of 0, 100, 200, 300, 400 and 500 ppm in M_1 and M_2 generations. They found a change in leaf, inflorescence, dwarfed, variegated plants. In the M_1 generation of first season, the concentration of 300 ppm produced plant with reddish leaf petiole in Giza 1. Plant of Giza 1 having inflorescence calyx with green dark colour was obtained with treatment of 300 ppm. The treatments of 100 and 200 ppm produced dwarfed plants in Giza 102 where as Giza 1 dwarfed plants were obtained with treatments of 200 and 400 ppm along with four variegated plants

2.2 Variability.

Sarafi (1976) irradiated the sunflower lines S-1 and S-41 with gamma rays at the dose of 6 and 12 kR. The mutant plants were analysed in M_2 generation for agronomic characters. The characters plant height, head diameter, seed weight, 100 seed weight and oil content showed significant differences between the two inbred lines. Genetic variability induced by 6 kR was lower than 12 kR for all characters except for mean weight of seed. Productive morphological mutants selected in M_2 population were more

promising than the genetic gain that may seen in late generation by selection and percentage of plants.

Lofgren and Ramaraje (1982) treated sunflower inbred Dahlgren H6B with Ethyl methane sulphonate (EMS) and N-methyl-N-nitro-N-nitrosoguanidine (NTG) at the dose of 50, 250, 500, 2500 and 5000 µg/ml. In M_2 generation, significant decrease in mean plant height was observed as increasing the treatment dose in both chemical mutagens compared to control. Significant earlier blooming was noticed in the treatment, EMS (250) and NTG (50). The EMS 5000 µg/ml had a mean of 100 achene weight which was significant lower than mean of the check. This can be attributed to the association with later bloom and lower oil content. The EMS 500, EMS 5000 and NTG 500 had significantly lower oil content than the checks. Unfortunately, achenes with significantly higher oil content was not noticed.

Seeds of well adopted, good combiner and widely used sunflower inbred line HA-89 treated by Martinez and Gimenez (1988) with EMS at 0.25, 0.50, 0.75 and 1% for 6 and 12 hours, respectively. In M_6 generation wide range of variations for all characters were observed. Some lines shows days earlier to flowering than the parental HA-89. Height also varied widely (44 to 168 cm), the average height was also taller than (100 cm) than the control (99 cm). The average of all lines for seed oil content was 48% higher than the control (46%). There was increase in head diameter (17.2) cm compared with control (11.3 cm). Thus the developed mutant plants with desirable agronomic traits can be used as parental line in hybridization programmes.

Giriraj *et al.* (1990) evaluated the mutant plants of HA-234 and RHA-274 in M_2 and M_3 generations for days to 50% flowering, test weight and oil content. There was appreciable increase in range, mean and SD for days to 50% flowering in M_2 and M_3 generations in both lines. The comparsion of mean value in different treatment with control showed a general trend of lower mean in M_2 generation, while in M_3 generation the mean value were almost at par with control. The mutagenic treatment had a significant effect on test

weight of both lines. A wide range in negative as well positive directions was recorded in M_2 and M_3 generations. In general, the mean was apparently higher in all mutagenic treatments than the control in both M_2 and M_3 generations. Oil content showed wide variability in both positive and negative directions in M_2 and M_3 generations. Both physical and chemical mutagens generates large variability for further breeding programmes.

Vranceanu and Iuoras (1990) evaluated the M_1 and M_2 plants obtained after irradiating the two inbred lines, CG-3663 and CG-3606 with gamma rays @ 100, 150 and 200 Gy. The results revealed that the irradiated line CG-3606 shows very slight variation in plant height, whereas that observed in CG-3663 was considerable in M_2 plants. There was considerable decrease in days to flowering in both irradiated lines with increasing treatment dose except in 200 Gy. There was significant increase in oil content of mutant plants of M_3 seeds of CG-3663(45.5%) and CG-3606(50-54.2%) compared to its control (34% and 39%), respectively. The mutants with high oil content can be forwarded to further generations for stability.

Christov (1996) developed a new sunflower mutant form by treating VNMIIK-8931 with gamma rays with a dose of 150 Gy. In M_7 generation significant changes were observed in plant height, head diameter, 1000 seed weight and oil content. The mean plant height was decreased in all obtained mutants (ranged from 115-165 cm as compared to control 215 cm). The mean head diameter was shifted in negative direction in all mutants. The mean values for 1000 seed weight and oil content were shifted in both positive and negative direction in all mutant.

Sanjeev and Giriraj (1997) irradiated two restorer lines of sunflower, IV83 (non-branching) and RLC-2 (branching) with gamma rays at 10 kR, 15kR and 20kR to induce polygenic variation for days to flowering, test weight and oil content. In the M_2 populations of both the genotypes analysis of variance indicated significant statistical difference between control and treated lines for all the three agronomic traits. Both negative and positive shift in mean

values were recorded in 10 kR dose for all the economic traits in both genotypes. There were changes in mean values of mutagen treated populations as compared with untreated populations. When compared with control in the M_2 populations, a decrease in mean value for days to flowering was observed in both genotypes. With respect to test weight, the decrease in mean value was observed only in RLC-2, while in IV83 the mean value increased in the treated populations as compared with the untreated populations. All irradiation treatments resulted in increased oil content in the M_2 population of both genotypes. The negative shift in mean value could be attributed to the occurence of deletions or harmful mutations.

The change in mean values in the mutagen treated populations were followed by change in variance for all characters. When compared to with control, in both genotypes, all mutagenic treatments resulted in increased variances for the traits. The magnitude of induced genetic variability tended to vary with characters and also with genotype at the same gamma radiation level. A critical examination of the result revealed that irradiation induced only a slight enhancement in the genetic component of variation for test weight and oil content.

Chikkadevaiah *et al*. (1998) evaluated 52 sunflower germplasms for use as confectionary types. Analysis of variance revealed significant differences among the genotypes for plant height, days to 50% flowering, head diameter, seed yield per plant, seed filling (%), 100 seed weight, per cent husk (%), and oil content (%). The estimates of GCV and PCV were high for seed yield per plant, per cent husk and head diameter. Low estimates of GCV and PCV values were for days to 50% flowering and seed filling (%), where as moderate for rest of the traits.

Ashok *et al*. (2000) studied variability for days to 50% flowering, days to maturity, plant height, diameter of capitulum, 100 seed weight, yield per plant and oil content. Analysis of variances indicated that mean square of variances were highly significant for all traits taken for study. This indicate that

there was enough variability in the present material. High GCV and PCV for yield per plant, 100 seed weight and harvest index indicating the scope of improvement through simple selection procedure for obtaining higher yield. Moderate GCV and PCV were noticed for days to 50% flowering, plant height, head diameter and low for days to maturity and oil content. Low variability is due to the presence of both positive and negative alleles for these characters in population.

Sujatha *et al.* (2002) evaluated fifty one inbred lines of sunflower to estimate phenotypic and genotypic variability. Analysis of variances revealed that there were a highly significant difference among the genotypes for all characters studied. High PCV and GCV were obtained for 100 seed weight, head diameter, husk per cent, plant height, seed test weight and oil content. Moderate PCV and GCV observed for hull per cent and low variability coefficients was obtained for days to 50% flowering.

Giriraj *et al.* (2004) created variability in two sunflower restorer lines, RHA-265 and 6D-1 by using EMS @ 0.5 % and 1 %, respectively. The mutant plants in both genotypes showed wide range of variability for days to flowering and test weight in M_3 generation. Early and late flowering genotypes were observed at 0.5% and 1.0% EMS concentration in RHA 265. In 6D-1, mutagenesis was helpful in isolating early flowering mutant lines as flowering ranged from 54 to 75 days in the mutant population against 65 to 81 days in the untreated population. For test weight mutagenesis had a negative effect in RHA-265 at both the concentrations. The negative shift in mean values could be attributed to the occurrence of deletions or harmful mutations. However the mutagenesis treatment was most effective in isolating high test weight mutants in 6D-1 as it is characterised by low test weight. High induced GCV was exhibited for days to flowering of RHA 265 @ 0.5 % and same line showed high GCV at 1 % for test weight. In case of 6D-1, the magnitude of genetic variability was low to medium for both traits.

Seneviratne *et al.* (2004) evaluated 200 best performing progenies of sunflower for days to 50% flowering, days to maturity, plant height, 100 seed weight, seed yield per plant and oil content. The values of PCV and GCV were high for seed yield and oil yield per plant. Plant height, head diameter, 100 seed weight and oil content showed moderate PCV and GCV values. Days to 50% flowering and days to maturity exhibited low PCV and GCV values.

Veeramani *et al.* (2005) induced variability in the groundnut variety, VRI 2 through chemical mutagens, i.e., EMS, DES and colchicines. The results showed increased genetic variability for the character studied. The phenotypic coefficient of variations were higher than genotypic co-efficient of variations for all the characters in all the chemical mutagens treatments. Among the treatments, 1.2 per cent DES showed higher PCV and GCV for pod yield and 0.8 per cent EMS showed maximum PCV and GCV for seed yield per plant.

Reddy and Reddy (2006) evaluated 100 germplasm accessions of sunflower for yield and yield contributing traits to study the extent of variability. The PCV and GCV found to the highest for seed yield per plant followed by seed filling (%), 100 seed weight, hull and oil content(%) indicating the presence of greater variability, which gives ample scope for improvement of these traits by simple selection. Moderate PCV and GCV have been observed for plant height and head diameter, where as low PCV and GCV for days to 50% flowering and days to maturity. Low variability for these characters emphasizes the need for generating more variability.

Sridhar *et al.* (2006) studied variability parameters for yield and its components in sunflower and reported that high GCV and PCV were found for 100 seed weight and seed yield per plant. The characters plant height, days to 50% flowering and days to maturity showed close correspondence between GCV and PCV, while seed yield per plant were most affected by environment.

Badigannavar and Murthy (2007) irradiated dry seed of TAG 24 groundnut variety with 100, 200, 300, 400 and 500 Gy. They studied the

mutant populations from M_5 to M_8 generations and the results revealed that considerable variations were obtained in all traits. As comparing the M5 with M_8 generation the mean values were decreased for oil content. Medium to low PCV and GCV were observed for oil content.

Khan *et al.* (2007) conducted a study using eight diverse genotypes of sunflower and observed that the PCV was higher than GCV for oil content, seed weight, days to maturity and plant height showed a closer correspondence between GCV and PCV. Higher PCV and GCV were found in plant height and seed yield per plant. Moderate PCV and GCV were observed in 1000 seed weight and oil content. Days to 50% flowering, days to maturity and head diameter recorded low values of GCV and PCV.

Mensah and Obadoni (2007) reported that both negative and positive shift in mean values were recorded as a result of chemical treatment in M_3 generation of groundnut. The phenotypic variance was higher than the genetic variance in mutagenesis induced population. However, the differences between the two measurements were low for pod yield and seed yield per plant inferring low environmental influence on these traits. Both negative and positive shift in mean values were recorded for 100 seed weight.

Encheva *et al.* (2008) created variability for both quantitative and qualitative characters in sunflower fertility restorer line, 147 R by treating the embryos with ultrasound waves. The mutant lines, 116 RM, 117 RM, 118 RM, 119 RM and 120 RM were evaluated biometrically in R_5 generation with control lines. The results revealed that significant changes occured in the plant height of mutant lines, which decreased their mean index value by 13.8 to 22.4 cm in relation to the control 147 R. Significant changes in leaf size were registered in all lines. A negative and highly significant change in mean values was observed for 100 seed weight from 19.4 to 23.2 g in all mutant lines. Negative genetic changes were registered for oil content in the kernel, 1000-seed weight, plant height, leaf width, leaf length, head diameter, number of branches, length of branches, diameter of lateral head, stem diameter, seed

width, seed length and seed thickness. The line 118 RM had significant per cent of significant negative changes (93%) for all investigated characters. It was concluded that mutation techniques in combination with embryo culture method produce desired variation which helps in breeding programs.

Jagadeesan *et al.* (2008) irradiated the sunflower varieties Morden and CO 4 with gamma radiation of 5, 10, 20 and 25kR. The results revealed that there was significant difference obtained in all treatments compared to control. In the M_2 generation of Morden, there was increase in mean value of most treatments for characters such as plant height, head diameter, 100 seed weight, days to maturity, seed yield per plant and oil content. Days to first flowering, plant height, head diameter and seed yield per plant showed negative shift in mean value in CO 4. Increases in induced variances to the increase in mutagen dose recovered in both genotypes.

Wani and Anis (2008) isolated the three-bold high yielding mutants, Pusa-212A, Pusa-212C, Pusa-212F in M_2 population of chickpea. Plant height increased significantly in all 3 mutants. Maximum plant height was recorded in Pusa- 212 F. A similarly significant increase in 100 seed weight and seed yield per plant was also recorded in Pusa-212 A and Pusa-212 F. It was evident from that the increase in mean seed yield per plant was due to an increase in the mean performance of other yield-contributing traits.

Arulbalachandran and Mullainathan (2009) evaluated mutant populations in M_2 generation of black gram of VBN-1 variety induced with 20, 40, 60, 80, 100, 120 kR of gamma rays and found that positive shift in mean values were observed in 40 kR and 60 kR for plant height, seed yield per plant and 100 seed weight and negative shift in 80 kR for these characters. The PCV and GCV expressed in terms of per cent points were comparatively high at 60 kR gamma rays for plant height, yield per plant and 100 seed weight. Maximum GCV was present for the grain yield per plant indicates that simple selection for yield may be advantageous as compared to its components under study.

Iqbal *et al.*,(2009) investigated genetic behaviour of quantitative traits in ten sunflower accessions. The analysis of variance revealed high significant difference among the sunflower genotypes for head diameter, oil content and achene yield. The oil content revealed lower GCV and PCV, which was an indication of limited scope for the selection of this character due to inadequate variability.

Khan and Goyal (2009) conducted mutation experiment in mungbean varieties, K-851 and PS-16 with EMS (0.2%), SA (0.02%) and gamma rays (20 kR). They elucidated that early maturing mutants, K-851-A (0.2% EMS), K-851-B (0.02% SA), K-851-C (20 kR gamma rays), PS-16-A (0.2%EMS), PS-16-B (0.02% SA) and PS-16-C (20 kR gamma rays) were significantly earlier than the parental varieties in M_5 generation. A significant gain in reducing the maturity period by 6 and 9 days was obtained for mutant lines, K-851-A and PS-16-A, respectively.

Kalukhe *et al.* (2010) studied genetic variability in sunflower comprising of 26 germplasm lines and one check, TAS-82 for 13 characters. They observed that values of PCV were slightly higher than GCV indicating the least influence of environment (ECV). High PCV and GCV were obtained for seed yield per plant, plant height and 100 seed weight. Low PCV and GCV were observed in days to 50% flowering, days to maturity and hull content.

Pavadai *et al.* (2010) reported significant increase in mean values of mutant population-CO_1 of soybean (50 kR- gamma rays) for plant height and yield per plant. Among the traits, high GCV and PCV values were observed for yield per plant and plant height.

Kumar and Ratnam (2010a) irradiated the sunflower varieties of USH-430 and SHSF-333 both independently and combined with gamma rays (2, 4, 6, 8 and 10 kR) and sodium azide (2, 4, 6, 8 and 10 mM). The results revealed that reduction in percentage of seedling survival was observed with an increasing gamma-ray dose in both varieties. The reduction of seed setting was observed with the increase of dose concentration of gamma rays in both

varieties. The mutagenic effectiveness was decreased with increased concentration of gamma rays and sodium azide in both the varieties. While, mutagenic efficiency increased with an increased dose of gamma rays in USH-430 and SHSF-333 but it was decreased in sodium azide.

Cvejic *et al.* (2011) used eight sunflower inbred lines for mutagen treatment using γ rays, fast neutrons and EMS. The results revealed that seedling height in all three treatments decreased with increasing dose. Reduction of seedling height was pronounced in line, HA-19 for except EMS treatment and the same line with chemical treatment is early maturing with large and round seeds. Lines OD-3369 and V-8931-OL exhibits high oil content among mutated lines i.e., 55% and 54% with high thousand seed mass. Lines, VK-66-tph, VK-66-tph_1-tph_2 and VK-66-OL-tph_2 showed low oil content with thick seed coat. A significant negative correlation was found between treatment and oil content for treatments and negative correlation exists between early flowering, short stature plants. Selection will be carried based on quantitative traits for future breeding programmes.

Hiremath *et al.* (2011) Estimated genetic variability, heritability and genetic advance for 12 different quantitative traits in 180 mutants derived from both the two spanish bunch groundnut cultivars, *viz.,* TPG-41 and GPBD-4 with chemical and physical mutagenic agents. The phenotypic and genotypic coefficient of variation showed wide variation for most of the characters in both the mutant populations. Phenotypic coefficient of variation was higher than the genotypic coefficient of variation for all the characters studied in the two mutant groups. The result revealed that induced genotypic and phenotypic variability for pod weight per plant was higher in both the two sets of mutants, indicating that there is greater scope for improvement of pod weight per plant in desirable direction. In the present investigation, the result also revealed that plant height had moderate genotypic and phenotypic variability in both the mutant groups. Both the mutant groups had moderate genotypic and phenotypic variability for 100 kernel weight,

pod yield and kernel yield for which there would be only moderate response to selection. The quality trait oil content recorded low genotypic and phenotypic variability indicating the narrow range of variability induced for these characters and restricting the scope of selection.

Kumar *et al.* (2011) evaluated 63 inbred lines including three hybrids of sunflower for estimating variability parameter in days to 50% flowering, days to maturity, plant height, head diameter, 100 seed weight, oil content & seed yield per plant. The analysis of variances revealed significant difference for all the traits studied. The range of variation was maximum for the characters plant height, days to 50% flowering, days to maturity, head diameter, oil content and seed yield per plant. In general, PCV values were marginally higher than GCV. Among the characters studied, seed yield per plant recorded highest PCV and GCV and the lowest value was recorded by days to maturity. While, PCV and GCV values were moderate for other characters *viz.,* oil content, test weight and head diameter. However low values were obtained for days to 50% flowering and days to maturity.

Makane *et al.* (2011) evaluated seventy nine recombinant version of sunflower, Morden and EC 68415 in Randomized Block Design. Based on their genetic variability studies they reported that PCV was slightly more than GCV for most of the character. Both high GCV and PCV values were observed for hull content, plant height, test weight, oil content and seed yield per plant and low values were found in days to 50% flowering, days to maturity and head diameter. The high estimates of these characters suggested high degree of genetic variability.

Hassan *et al.* (2012) evaluated 10 sunflower genotypes for plant height, head diameter, seed yield per plant, 100 seed weight and oil content. Analysis of variance showed high significant difference among the genotypes for the traits, *viz.,* plant height, head diameter and 100 seed weight. The phenotypic variance was slightly higher than the genotypic variance for all the traits except plant height. There was a narrow range of differences between

genotypic coefficient of variations and phenotypic coefficient of variations for most of the characters indicating less environmental influences on phenotypic expression of the characters and they were mostly governed by genetic factors. Plant height, 100 seed weight and seed yield per plant revealed high GCV and PCV. However the remaining traits showed moderate GCV and PCV.

Mahmoud (2012) observed significant difference among 19 inbred lines of sunflower for plant height, head diameter, achene weight per plant and 1000 achene weight. The head diameter, achene weight per plant, 1000 achene weight exhibits high GCV and PCV, whereas moderate values for plant height and low for days to 50% flowering was recorded.

Neelima *et al.* (2012) analysed variability for days to 50% flowering, plant height, head diameter, 100 seed weight and seed yield per plant in 45 entries of sunflower. The analysis of variance revealed significant differences among the genotypes for all the five characters studied indicating worth of genetic material under study. The range of variation was found to be maximum for plant height followed by seed yield per plant which infers better scope for selection of this trait. High GCV and PCV were noted for seed yield and plant height. Moderate values of GCV and PCV were observed for plant height, 100 seed weight and head diameter. Days to 50% flowering has lower GCV and PCV values and less scope exits for improvement of this trait.

Roychowdhury *et al.* (2012) revealed that there was a significant increases in mean values and genetic variability of studied traits in M_2 generation of all treatments (0.2, 0.4, 0.6 and 0.8% EMS) in mungbean. The phenotypic coefficient of variation (PCV) was higher than its genotypic counterpart (GCV) for all the studied traits. The highest GCV and PCV for plant height was recorded in 0.4% EMS treatment.

Wani *et al.* (2012) exposed the Avrodhi variety of chickpea seeds with 0.1 % and 0.2 % EMS and 0.01 % and 0.02 % SA for 6 hours. The EMS treatments were more effectual in increasing the mean values than SA. High

GCV and PCV was recorded for seed yield per plant and low in 100 seed weight of M_4 generation.

Natikar *et al.* (2013) studied genetic variability in M_3 generations of mutant population of sunflower varieties, Morden and DSF 15B. The phenotypic and genotypic coefficient of variations were high for plant height and seed yield per plant. Moderate GCV & PCV values exhibited for head diameter, seed filling(%), 100 seed weight, hull content and oil content of Morden populations, where as high GCV and PCV values for seed yield and moderate values for plant height, head diameter, 100 seed and oil content exhibited in case of DSF 15B mutants. The traits with high GCV and PCV are under the influence of genetic control and simple selection can be practiced for further improvement of these characters. The mutants showed a wide range of variation which provides ample scope for selection of superior and desired mutants.

Sami *et al.* (2013) in 30 sweet sorghum genotypes revealed that the phenotypic coefficient of variation was greater than the genotypic coefficient of variation for most traits studied. The GCV was near to PCV for traits like days to 50% flowering, plant height and sugar content, indicating a highly significant effect of genotype on phenotypic expression for these traits with very little effect of environment.

Sudrik *et al.* (2014) in 107 germplasm lines of sunflower recorded highest GCV and PCV and their close correspondence for seed yield per plant, and 100 seed weight. Moderate GCV and PCV exhibited for plant height, head diameter, oil content and 100 seed weight, whereas low GCV and PCV noted for days to 50% flowering, days to maturity, hull content and seed filling percentage.

Banakar *et al.* (2015) generated variability in parental lines of sunflower parental lines of hybrids, RFSH-130 (CMS-104B and R630), maintainer lines of RFSH-1 (CMS-103B) and KBSH-44 (CMS-17B) by exposing them with gamma rays at 10, 15 and 20 kR. The mutagenic

populations showed a wide range of variability in M_1 generation. The characters, plant height, days to 50% flowering, head diameter, days to maturity and seed yield per plant showed a negative shift from the control to all the doses in all the four genotypes except 10 and 15kR doses in days to maturity of R630 genotype. The selected mutants with increased mean values, high heritability and genetic advance for various traits studied in all the genotypes studied may be used for crop improvement programmes.

Gunasekaran and Pavadai (2015) irradiated dry seed of groundnut variety, VRI 2 with physical mutagen gamma rays and observed that in M_1 generation the parameters such as days to first flowers, plant height and seed yield per plant were significantly decrease with increasing dose of mutagenic treatment. In M_2 generation the highest mean value for plant height, 100 seed weight, kernel yield per plant and oil content were recorded in 50 KR gamma rays and 0.5 % EMS treatment than the other treatments.

Kham *et al.* (2015) induced variability in shweni-15 of sorghum variety with gamma rays at 0Gy-800Gy. The results of M_2 generation revealed that there was both positive and negative shift in mean was observed in plant height. High GCV and PCV were observed in plant height and seed yield per plant. For 100 seed weight, high GCV and PCV exhibited in 200Gy and 500Gy dose. The highest average genetic variation in M_2 generation plants occurred in most of the traits in 300Gy followed by 400Gy. In this study, gamma ray irradiation with the treatment of 300Gy and 400Gy were effectively leads to genetic variation for Sorghum of Shweni 15.

Kulmi and Mogali (2016) induced mutagenesis using chemical mutagen- EMS @ 0.1, 0.2, 0.3, 0.4, 0.5 % in two linseed varieties, Indira Alsi and NL-115. In M_2 population, they envisaged that high GCV and PCV were exhibited for seed yield per plant under all EMS treated M_2 progenies of Indira Alsi and NL-115 genotype.

Rani (2016) carried out genetic variability study in 50 sunflower genotypes in Randomized Block Design with 3 replications. Analysis of

variance exhibits significant difference among genotypes for all characters. High GCV and PCV were observed for seed yield per plant, 100 seed weight, and hull content. Moderate GCV and PCV recorded for plant height, head diameter, seed filling percentage and oil content. Days to 50% flowering and days to maturity showed low GCV and PCV.

Wadikar *et al.* (2018) investigated the 45 sweet sorghum genotypes for total soluble sugar, non-reducing sugar and reducing sugar. It showed high value for genotypic and phenotypic co-efficient of variation for total sugar content and low values for days to 50% flowering.

2.3 Heritability and genetic advance.

Sarafi (1976) irradiated the sunflower lines S-1 and S-41 with gamma rays at the dose of 6 and 12 kR. The mutant plants were analysed in M_2 generation for agronomic characters. The heritability estimates for plant height (2.18 to 22.2%), head diameter (7.57 to 20.89%), seed weight (2.32 to 9.62%) and oil content (8.04 to 22.66%) were not high enough to indicate that considerable amount of genetic variability was present in M_2 population. Heritability for mean seed weight (24.46 to 35.26) was high enough to start a pedigree selection from M_4 population.

Tariq *et al.* (1992) reported high heritability coupled with high genetic advance for seed yield and oil content, indicated the influence of additive effects. Where as high heritability with low genetic advance was seen in plant height and head diameter reflecting dominance and epistatic nature of inheritance.

Sanjeev and Giriraj (1997) irradiated two restore lines of sunflower with gamma rays at 10 kR, 15kR and 20kR to induce polygenic variation for days to flowering, test weight and oil content. In the M_2 populations of both the genotypes, low to high estimates of heritability and genetic advance were recorded for all these traits. High estimates of heritability were accompanied with high genetic variability and high genetic advance in most of the treated populations.

Chikkadevaiah *et al.* (1998) in confectionary sunflower germplasm revealed that the days to 50% flowering, per cent husk and seed oil content (%) exhibited high heritability, whereas plant height, head diameter, seed yield per plant, seed filling (%) and 100 seed weight exhibited moderate heritability. These traits also exhibited moderate to high genetic advance.

Ashok *et al.* (2000) in 40 sunflower hybrids noticed that high heritability estimates were observed for days to 50% flowering, days to maturity, plant height, head diameter, 100 seed weight, yield per plant and oil content. High heritability coupled with high genetic advance were recorded for days to 50% flowering, plant height, 100 seed weight and yield per plant. Which showed that these characters are amenable for improvement by selection particularly through mass selection and this may attributed to additive gene effects. Days to maturity and oil content exhibit moderate heritability and low genetic gain, which indicates the presence of dominance and epistatic effect. Thus selection based on randomly may be followed for improving these specific characters.

Sujatha *et al.* (2002) evaluated fifty one inbred lines of sunflower for estimates of heritability and genetic advance. High heritability values coupled with high genetic advance were recorded for plant height and yield per plant. High heritability coupled with moderate genetic advance was observed for husk percentage. High heritability along with low genetic advance was noticed for the head diameter, days to 50 per cent flowering and 100 seed weight. Selection is effective for those characters with high heritability estimate and high genetic advance.

Giriraj *et al.* (2004) created variability in two sunflower restorer lines RHA-265 and 6D-1 by using EMS @ 0.5 % and 1 %, respectively. In RHA-265, the estimates high heritability coupled with low genetic advance for days to flowering while for test weight it was accompanied by high genetic advance. It appeared both additive and non additive type of gene action were involved for days to flowering in mutant population. However for test weight,

additive genetic portion was predominant. In case of 6D-1the heritability estimates were low to medium coupled with low genetic advance for both the traits indicating the major role of non-additive gene action along with epistatic interaction.

Seneviratne *et al.* (2004) recorded heritability and genetic advance as per cent of mean in 200 best performing plant of sunflower. High heritability associated with high genetic advance as per cent of mean were recorded for head diameter and oil yield per plant indicating lesser environment influence on these characters and a role of additive gene action. High heritability estimates associated with moderate genetic advance as per cent of mean was recorded for plant height, 100 seed weight and oil content suggesting that these characters were less influenced by environment but governed by both additive & non additive gene action. High heritability estimates associated with low genetic advance recorded for days to 50% flowering, days to maturity and seed yield showed that these characters are influenced by the environment due to its non-additive gene action.

Veeramani *et al.* (2005) induced variability in the groundnut variety, VRI 2 through chemical mutagens i.e., EMS, DES and colchicines. The results showed heritability and genetic advance as per cent of mean for different characters were found to be more in the treated populations. In case of seed yield per plant, maximum heritability and genetic advance as per cent mean was recorded at 0.8 % EMS. Plant height at 0.8 % EMS showed high heritability with moderate genetic advance.

Reddy and Reddy (2006) evaluated 100 sunflower germplasm accessions and two checks in Randomized Block Design with two replications for days to 50% flowering, days to maturity, plant height, head diameter, 100 seed weight, seed yield per plant and oil content. High heritability coupled with high genetic advance over mean has been recorded for per cent seed filling (%), seed yield, hull per cent, oil percentage, plant height, 100 seed weight suggesting better scope for improvement of these characters through direct

selection. High heritability with moderate genetic advance has been observed for days to 50% flowering and maturity, low heritability with low genetic advance over mean for head diameter indicating greater influence of environment in the expression of these characters.

Sridhar *et al.* (2006) reported that high heritability with genetic advance as per cent of mean were found in 100 seed weight and seed yield per plant in sunflower.

Arshad *et al.* (2007) observed high heritability for plant height in twenty sunflower hybrids. Moderate heritability values were seen in days to maturity, 100 seed weight, oil content, while head diameter and seed yield exhibits low values. It suggests that most likely the heritability is due to additive gene effects and selection may be effective.

Badigannavar and Murthy (2007) induced the gamma rays treatment to TAG 24 groundnut variety @ 100, 200, 300, 400 and 500 Gy. They studied the mutant populations from M_5 to M_8 generation and the results revealed that greater heritability coupled with higher genetic advance was observed for plant height, seed yield, hundred seed weight and oil yield, which was due to additive gene action. Oil content in M_8 generation showed higher heritability, but with lower genetic advance because of non-additive gene action.

Khan *et al.* (2007) reported heritability and genetic advance in eight diverse genotypes of sunflower. High heritability coupled with low-high genetic advance as per cent of mean were exhibited for plant height and oil yield. Low heritability with high genetic advance as per cent of mean were seen in seeds per head and seed yield per plant, but days to 50% flowering exhibited low genetic advance and heritability. High heritability with low genetic advance as per cent mean were observed for oil content, 100 seed weight and days to maturity. The traits with high heritability and high genetic advance are reliable for plant breeders in selection to increase seed yield.

Jagadeesan *et al.* (2008) irradiated the sunflower varieties Morden and CO 4 with gamma radiation with 5, 10, 15, 20 and 25kR. High heritability and genetic advance was observed for 100 seed weight for all the treatments. However, moderate heritability and genetic advance was observed for plant height, head diameter, days to maturity, seed yield per plant and oil content for all the treatments. Heritability and genetic advance as percentage of mean were maximum at 20 kR for seed yield per plant as well as for oil content, head diameter and 100 seed weight. In CO 4, the heritability and genetic advance as percentage of mean were maximum at 5 kR for seed yield per plant and other traits such as head diameter and days to maturity. The high heritability and genetic advance was observed at 10 kR in CO 4 for oil content, plant height and days to maturity. Hence, selection will be applied in the populations treated with 20 kR in Morden and 5 kR and 10 kR in CO 4 to obtain high seed and oil yielding progenies. The mutants isolated with increased mean values, high heritability and genetic advance may be useful in crop improvement.

Wani and Anis (2008) isolated the three-bold high yielding mutants, Pusa-212A, Pusa-212C, Pusa-212F in M_2 population of chickpea. All these mutant plants showed a high degree of heritability for almost all quantitative traits compared to control. Among the traits studied, high heritability revealed in 100 seed weight followed seed yield per plant and plant height.

Arulbalachandran and Mullainathan (2009) evaluated variations in M_2 generation of black gram of VBN-1 variety induced with 20, 40, 60, 80, 100 and 120 kR of gamma rays and observed that high heritability with high genetic advance as per cent of mean for plant height, yield per plant and 100 seed weight at 60 kR of gamma rays, indicates preponderance of additive gene action of expression of these traits.

Iqbal *et al.* (2009) investigated genetic behaviour of quantitative traits in ten sunflower accessions and reported that oil content exhibited

maximum magnitude of broad sense heritability and moderate value of genetic advance, which advocated that this character might be improved through selection. This was an indication of the involvement of enough genetic and additive effects in the inheritance of oil contents in sunflower.

Khan and Goyal (2009) conducted mutation experiment in mungbean varieties K-851 and PS-16 with EMS (0.2%), SA (0.02%) and gamma rays (20 kR). They elucidated that high values of heritability with genetic advance were revealed in days to maturity in M_5 generation. This indicates that the induced variability in mutant lines was fixed by selection.

Arshad *et al.* (2010) recorded high heritability coupled with high genetic advance as per cent of mean values for days to flower initiation, days to maturity, plant height and moderate values of both for oil content, 100 seed weight and other traits (head diameter, seed yield) showed low- moderate values in sunflower.

Kalukhe *et al.* (2010) evaluated 26 germplasm lines of sunflower and reported high heritability with higher genetic advance for seed yield per plant and 100 seed weight. High heritability coupled with moderate genetic advance were found in days to 50% flowering, days to maturity, plant height, head diameter, hull content and oil content.

Pavadai *et al.* (2010) studied mutant population CO_1 of soybean for plant height, number of branches per plant, number of pods per plant, yield per plant and protein content. Among the traits, high heritability coupled with genetic advance as per cent of mean observed in yield per plant and plant height.

Hiremath *et al.* (2011) exposed two improved Spanish bunch cultivars of groundnut, TPG-41 and GPBD-4 to mutagenic treatments for induction of genetic variability. They revealed high heritability with expected genetic advance for plant height, 100 kernel weight, pod yield and kernel yield in both mutants.

Kumar *et al.* (2011) assessed 63 genotypes for heritability and genetic advance as per cent of mean for days to 50% flowering, plant height, days to maturity, test weight, seed yield per plant and oil content. High heritability coupled with high genetic advance as per cent of mean exhibited by seed yield per plant, oil content, test weight, head diameter and plant height. High heritability with low genetic advance as per cent of mean elucidated in days to 50% flowering and days to maturity. It indicated that improvement in seed yield can be achieved by adopting simple selection process with high heritability and genetic advance as per cent of mean.

Makane *et al.* (2011) studied 79 recombinant versions of sunflower Morden and EC 68415. They reported high heritability coupled with high genetic advance as per cent of mean for plant height, hull content and seed yield per plant. High heritability with moderate genetic advance was observed for oil content and test weight. Low estimates of heritability with low genetic advance were exhibited by days to 50% flowering and volume weight.

Hassan *et al.* (2012) estimated heritability and genetic advance as per cent of mean in 10 sunflower genotypes for plant height, 100 seed weight, head diameter, oil content and seed yield per plant. High heritability and high genetic advance was exhibited by plant height. High heritability and moderate genetic advance were shown by oil content and seed yield per plant. Head diameter and 100 seed weight showed high heritability but low genetic advance. The highly heritable character with high or moderate genetic advance could be further improved with individual plant selection.

Mahmoud (2012) investigated 19 inbred lines of sunflower and reported that high heritability with high genetic advance as per cent of mean were observed for plant height, head diameter, achene weight and 1000-achene weight indicated that these traits were governed by additive gene effects. Heritability along with genetic advance as per cent of mean was more helpful in predicating gain under phenotypic selection than heritability estimate only.

Neelima *et al.* (2012) noticed high heritability coupled with high genetic advance as per cent of mean for plant height inferring this trait was governed by additive gene action and simple selection is effective. High heritability coupled with low genetic advance as per cent of mean was noted for days to 50% flowering suggesting selection was ineffective due to high influence of environment . Low heritability and high genetic advance as per cent of mean was observed for seed yield indicates yield is governed by additive gene action and is highly influenced by favourable environments. Low heritability coupled with low genetic advance as per cent of mean was found in traits, head diameter and 100 seed weight.

Roychowdhury *et al.* (2012) observed high heritability combined with high genetic advance as per cent of mean on 0.4% EMS for days to flowering in mungbean. High heritability with moderate genetic advance as per cent of mean was recorded in 0.6% and 0.8% EMS for days to flowering indicating that this character was governed by additive gene interaction. High heritability coupled with low genetic advance as per cent of mean was recorded in all EMS treatment, especially 0.4% EMS for plant height indicating non-additive gene action for this trait.

Wani *et al.* (2012) exposed the Avrodhi variety of chickpea seeds with 0.1 % and 0.2 % EMS and 0.01 % and 0.02 % SA for 6 hours. High heritability coupled with high genetic advance exhibited for yield per plant of 0.2 % EMS. 100 seed weight shows low heritability with low genetic advance among mutant plants of 0.1 % EMS.

Natikar *et al.* (2013) estimated heritability and genetic advance as per cent of mean in M_3 generation of sunflower mutants in Morden and DSF 15B. The heritability and genetic advance as per cent of mean estimates were high for plant height, 100 seed weight, oil content and seed yield in Morden mutants. In DSF 15B mutants, the estimates were also high for plant height, hull content and oil content. Days to 50% flowering, days to maturity, head

diameter and seed filling percentage recorded moderate heritability and genetic advance as per cent of mean in both the mutant plants.

Malek *et al.* (2014) in 27 mutant plants of soybean revealed high heritability with high genetic advance as per cent of mean for plant height and 100 seed weight. Among the traits, days to maturity had relatively low heritability with moderate genetic advance.

Sudrik *et al.* (2014) in 107 germplasm lines of sunflower recorded high heritability coupled with high genetic advance as per cent of means for seed yield per plant, plant height, 100 seed weight and head diameter revealed scope for their improvement through direct selection.

Cvejic *et al.* (2015) exposed eight sunflower inbred lines with gamma rays, fast neutrons and EMS. In M_6 and M_7 generation, high heritability estimates were highest for earliness, plant height and head diameter, while yield and oil content showed moderate values. Genetic advance as per cent of mean was highest for head diameter (88.95%) of mutant line, L4MBr; plant height (59.72%), oil yield (55.39%) and seed yield (55.350%) of R3MT. Heritability increased from M_6 to M_7 generation indicating that improvement or selection could be based on these characters.

Kham *et al.* (2015) estimated heritability and genetic advance in mutant population of shweni-15 of sorghum variety with gamma rays at 0Gy-800Gy and in M_2 generation results revealed that high heritability with high genetic advance as per cent of mean for plant height and seed yield per plant. Hundred seed weight shows moderate heritability with moderate genetic advance as per cent of mean.

Kulmi and Mogali (2016) induced mutagenesis using chemical mutagen- EMS @ 0.1, 0.2, 0.3, 0.4, 0.5 % in two linseed varieties, Indira Alsi and NL-115. In M2 population, they envisaged that high heritability with moderate to high genetic advance were observed in plant height and yield per plant in both the mutant populations and days to 50 per cent flowering in NL-

115 mutant population. This indicates possibility of obtaining high response to selection for these traits owing to their high transmissibility.

Rani (2016) carried out research in 50 sunflower genotypes to find heritability and genetic advance as per cent of mean. High heritability coupled with moderate to high genetic advance as per cent of mean recorded for in days to 50% flowering, plant height, head diameter, seed filling percentage, seed volume weight, oil content, protein content and days to 50% flowering.

Sir *et al.* (2016) recorded high heritability coupled with high genetic advance as per cent of mean in six generations (P_1, P_2, F_1, F_2, BC_1, BC_2) of sunflower for days to 50% flowering in summer and winter season, plant height and seed yield per plant in summer. These characters in general could be possible to improve from one cycle of selection.

Kulmi *et al.* (2017) isolated the high yielding mutants by treating the two varieties of linseed, Indira Alsi and NL-115 with EMS @ 0.1, 0.2, 0.3, 0.4 and 0.5 % for 18 hours respectively. High heritability coupled with high genetic advance exhibited for yield per plant, where as days to 50 % flowering and days to maturity had high heritability with low genetic advance.

Wadikar *et al.* (2018) investigated 45 sweet sorghum genotypes for heritability estimates and the results revealed that the characters total soluble sugar, non reducing sugar and reducing sugar exhibited high heritability. High estimate of genetic advance as per cent of mean were observed for total soluble sugar, reducing sugar and non-reducing sugar. Thus, considering the estimate of heritability and genetic advance together, it is evident that reducing sugar, non-reducing sugar and total soluble sugar are most improvement characters.

MATERIALS AND METHODS

CHAPTER III

MATERIALS AND METHODS

The present study entitled "Mutation studies in confectionary type of sunflower (*Helianthus annuus* L.)" was conducted during *kharif*, 2017 at Experimental Farm, Department of Agricultural Botany, College of Agriculture, Latur. The details of materials used and methods adopted during the course of investigation are described as below.

3.1 Experimental material

For the present study, the confectionary sunflower genotypes were obtained from Oilseeds Research Station, Latur. The colour of seed and name of the genotypes are presented as below.

Details of sunflower genotypes.

Sr.No	Name of the genotypes	Colour of the seed
1.	EC 625693	Black
2.	EC 318761	White Stripped
3.	SCG 62	White

Chemical mutagenic treatments:

The dry seeds of sunflower genotypes were exposed to different concentrations of freshly prepared sodium azide solution (100, 200, 300 ppm) for 4 hrs. The seeds of control were also soaked in distilled water for 4 hours. After, treatment with sodium azide, the seeds were thoroughly washed in running tap water for ten minutes to detain excess exudates, chemicals and other materials from seeds.

The treated seeds were sown for raising M_1 generation during *rabi*, 2016-17 at Experimental farm, Department of Agricultural Botany,

College of Agriculture, Latur.For raising M_2 generation, seeds from each M_1 plants were harvested separately and seeds were collected. The seeds of M_1 plants from each treatment along with control were used for raising the M_2 generation on plant to row basis. The field conditions was same as that of M_1 generation. The treatments are given in below.

Details of mutagenic treatments.

Genotype	Number of treatments	Concentration of chemical(in ppm)
EC 625693	T_1	0
	T_2	100
	T_3	200
	T_4	300
EC 318761	T_5	0
	T_6	100
	T_7	200
	T_8	300
SCG 62-MONO	T_9	0
	T_{10}	100
	T_{11}	200
	T_{12}	300

3.2 Experimental methods

3.2.1 Experimental Design

The experimental material was evaluated during *kharif* season, *2017*-18 at Experimental farm, Department of Agricultural Botany, College of Agriculture, Latur in two replicates Randomized Block Design (RBD). Sowing was carried out at the spacing of 60 cm and 30 cm between the rows and plants, respectively. The method of sowing was followed by dibbling. The recommended dose of fertilizer was applied, 60:30:30 kg NPK/ha. The recommended cultural practices including plant protection measures were followed to maintain healthy crop up to maturity.

3.3 Observations recorded

Randomly equal number of plants from each replications were selected for each treatment for recording observations except for control treatments as twelve. Average values of each character were determined from these observational plants.

3.3.1 Days to 50 per cent flowering

Date of sowing to the flowering of fifty per cent plant the number of days in each plot were measured and recorded as days to 50 per cent flowering.

3.3.2 Days to maturity

Days to maturity were recorded as number of days required from sowing to maturity on the plant. The head colour turned to lemon yellow was regarded as signs of maturity.

3.3.3 Plant height (cm)

The height of plant in cm was recorded on each plant from base of the plant to the base of head.

3.3.4 Head diameter (cm)

Head diameter was recorded in centimeter at maturity with the help of metric scale.

3.3.5 Seed filling (%)

It is the per cent ratio of number of filled seeds to the total seeds of each selected plants in each treatment of each genotype were measured and then seed filling percentage was calculated.

$$\text{Seed filling (\%)} = \frac{\text{Number of filled seeds in head (F)}}{\text{Number of total seeds (F+U)}} \text{ x } 100$$

Where,

F= Filled seeds

U= Unfilled seeds

3.3.6 Hull content (%)

Ten grams of well filled seeds was taken from each plant and it was dehulled and measured as hull content.

Hull content = Weight of Hull (g) x 100 /Weight of seed (10g)

3.3.7 100 grain weight (gm)

One hundred filled seeds were randomly picked and the test weight was recorded in grams using weighing balance.

3.3.8 Oil content (%)

A random bulk well dried and filled seeds sample were taken from selected plants produce weighing 15 grams. The oil content percentage was measured using NMR facilities available at Indian Institute of Oilseeds Research (IIOR), Hyderabad, Telangana, India.

3.3.9 Seed yield per plant (g)

The cleaned produce of selected plants was weighed in gram with

the help of weighing balance and average weight was measured as seed yield per plant.

3.3.10 Sugar content (%)

Total sugars (Reducing and non-reducing) of were find out by Benedicts methods.

3.3.10.1 Estimation of reducing sugars by Benedict's method (%)

Digestion of seed sample:

The whole seed weighted 1gm was digested in 10 ml of Nitric acid (HNO_3) and Perchloric acid ($HCLO_4$) @ 9:1 ratio and the volume was maked up to 100 ml with distilled water and the solution was prepared for each treatments for total sugar content analysis.

Principle:

The cupric copper in alkaline solution in reduced by glucose, lactose and maltose. The cuprous oxide formed, combines with potassium sulphocyanide (KCNS) in the solution to form a bulky white cuprous thiocyanate. This prevents the formation of red or yellow precipitate. On completion reduction, whole of $CuSO_4$ disappears and the solution shows no blue colour.

Reagents:

1. Benedict's quantitative reagent.
2. Anhydrous sodium carbonate.
3. Standard solution of glucose.
4. Solution of glucose or any of the reducing sugars.

Procedure:

1. Standardization of Benedict's quantitative reagent:

Pipette 25ml of Benedict's reagent in 100 ml flask with a long narrow neck. Add 2 to 3 g of anhydrous sodium carbonate and a few pieces of porcelain. Heat the flask on a burner. Keep the contents of flask

boiling throughout the titration period. Take the standard glucose solution (0.5g/100ml) in a burette and slowly run this solution into the boiling reagent. A bulky white precipitate of cuprous thiocyanate will form. Add the glucose solution drop wise until the last trace of the blue colour due to $CuSO_4$ disappears.

Allow the titration mixture to cool. The white precipitate settles down. Supernatant liquid exhibits light green colour. If the fluid shows a bluish colour, boil the contents and add more glucose solution until the end point is reached. If the supernatant liquid show green tinge then excess glucose has been added. The titrate until constant readings are obtained.

2. Determination of reducing sugar:

Take the test solution into the burette and repeat the titration as in the standardization experiment. End point of the titration is reached when the supernatant liquid becomes greenish. Repeat the titration to obtain constant reading.

3.3.10.2 Estimation of non reducing sugars by Benedict's method (%)

Principle:

The sucrose is inverted by boiling with mineral acid to obtain invert sugar solution. It is titrated Benedict's quantitative reagent as in the estimation of glucose.

Reagents:

1. Benedict's quantitative reagent.
2. Anhydrous sodium carbonate.
3. Hydrochloric acid (1N).
4. Sodium hydroxide (1N).
5. Sucrose solution about 2.5% or any of the non-reducing sugars.

Procedure:

Pipette 25 ml of the sucrose solution in a beaker; add 12 ml of 1N

HCL. Stir well and heat on flame. Heat to boiling. Allow the content to boil for two minutes. Cool under running water. Add with stirring 12 ml of 1N NaOH (alkali equivalent to acid). Confirm the neutralization of acid by testing a small drop of solution with red litmus. It should become blue. Transfer the contents of the beaker to a 250 ml volumetric flask. Make up the solution to 250 ml. Mix thoroughly by inverting the flask several times. The hydrolyzed solution of sucrose thus formed, is called **'Invert sugar solution'**.

Fill this solution in the burette and titrate it with 25 ml. Benedict's quantitative reagent as described in the determination of glucose. The end point is obtained in the same manner as described for glucose estimation. Repeat the titration until constant reading is obtained.

Total sugar content (%) = Reducing sugar + Non reducing sugar.

3.4 STATISTICAL ANALYSIS

The data for all the characters was analysed using Indostat Services, Hyderabad installed at Department of Agricultural Botany, College of Agriculture, Latur.

3.4.1 Analysis of variance (ANOVA)

The replication means based on selected plants for all ten yield and yield contributing characters used for analysis. The analysis was based on the model suggested by Panse and Sukhatme (1985).

Sources of variation	d.f.	MSS	Expected mean sum of squares
Replication	(r-1)	RSS	$\sigma^2e + t\sigma^2r$
Treatment	(t-1)	TSS	$\sigma^2e + r\sigma^2t$
Error	(r-1) (t-1)	ESS	σ^2e

Where,

r = Number of replications.

t = Number of treatments.

d.f. = Degrees of freedom.

RSS = Replication sum of squares

TSS = Treatment sum of squares

ESS = Error sum of squares

Standard error (SE), critical difference (CD) and coefficient of variation (CV) were calculated as follows:

$$SE(\pm) = \sqrt{2Me / r}$$

$$CD = SE \times \sqrt{2} \times \text{'t'} \text{ (at error degrees of freedom)}$$

$$CV(\%) = \sigma / \bar{x} \times 100$$

Where,

Me : Error mean square

t : Table 't' value at error degrees of freedom at 5 and 1 per cent level.

r : Number of replication

σ : Standard deviation

$\bar{x}$: Mean

3.4.2 Variability, coefficient of variance, heritability and genetic advance

3.4.2.1 Variability

The genotypic and phenotypic variances were calculated as per the formulae given by Burton and Devane (1953).

Genotypic variance ($\sigma^2 g$)

$$= \frac{\text{Mean sum of square due to treatments} - \text{Mean sum of square due to error}}{\text{Number of replications}}$$

Phenotypic variance ($\sigma^2 p$) = $\sigma^2 2p + \sigma^2 e$

$\sigma^2 e$ = Error variance

3.4.2.2 Coefficient of variance

The genotypic (GCV) and phenotypic (PCV) coefficients of variation were calculated as per the formulae given by Burton (1952).

GCV = $\sigma g / \bar{x}$ x 100

PCV = $\sigma p / \bar{x}$ x 100

Where, σg and σp are genotypic and phenotypic standard deviations, respectively. $\bar{x}$ is grand mean.

3.4.2.3 Heritability (Broad Sense)

Heritability in broad sense was estimated by using the formula given by Allard (1960).

Broad sense heritability ($h^2 bs$) = $\sigma^2 g / \sigma^2 p$ x 100

Where,

$\sigma^2 g$ = Genotypic variance

$\sigma^2 p$ = Phenotypic variance

3.4.2.4 Genetic advance (GA)

It was calculated as per the formula proposed by Burton (1952).

GA = (K) ($\sigma^2 p$) ($h^2 bs$)

Where,

GA = Expected genetic advance under selection

K = Selection differential (2.06) at 5 per cent intensity of selection

$\sigma^2 p$ = Phenotypic standard deviation

$h^2 bs$ = Heritability in broad sense

3.4.2.5 Genetic advance as per cent of mean (GA as % of mean)

Genetic advance as per cent of mean was calculated as per the formula.

GA as per cent of mean= GA/$\bar{x}$ x 100

Where,

GA=Genetic advance

$\bar{x}$ = grand mean of the character

RESULTS

CHAPTER IV

RESULTS

The present investigation entitled "Mutation studies in confectionary type of sunflower (*Helianthus annuus* L.)" was conducted in M_2 populations developed by giving sodium azide treatments of 100 ppm, 200 ppm, 300 ppm along with control to three confectionary sunflower genotypes EC 625693, EC 318761 and SCG 62. The results obtained on morphological mutants, mean performance, variances and genetic parameters are presented in following lines.

4.1 Morphological mutants

Different types of macro mutants were observed during the present investigation. The results of those are presented as below.

4.1.1 An extreme early dwarf mutant

This mutant was observed in EC 625693 of 100 ppm and 300 ppm treatments with reduction in plant height and flowering accompanied by small head size.

Plate I

4.1.2 Mosaic leaf

Mosaic leaf mutant characterized by uninterrupted green were reported in SCG 62 of 100 ppm treatment.

Plate II

4.1.3 Rosette leaf

One of the mutant from SCG 62 of 300 ppm treatment appears rosette leaf arrangement and characterized by reduction in internodal length.

Plate III

4.1.4 Curved ray florets

This type of mutant was characterized by curved ray florets and increased ray florets length. It was observed in EC 318761 of 200 ppm treatment.

Plate IV

4.1.5 Dwarf mutant

EC 625693 and EC 318761 of 200 ppm treatments showed dwarf mutant with reduction in plant height, internodal size and head diameter.

Plate V

4.1.6 Basal stem bifurcation

Basal bifurcated stem mutant viewed in SCG 62 of 100 ppm and 200 ppm treatments and EC 318761 of 300 ppm treatment.

SCG 62 @ 100ppm NaN_3

SCG 62 @ 100ppm NaN_3

EC 318761 @ 300 ppm NaN_3

Plate VI

4.1.7 Variegated leaf

EC 625693 of 300 ppm treatment displayed the variegated leaves with patchy green (Chlorophyll mutations) mutant.

Plate VII

4.1.8 Corrugated leaf

This mutant leaf shaped into alternating parallel grooves and ridges on upper leaves and presented in EC 625693 of 300 ppm treatment.

Plate VIII

4.1.9 Patchy albino

Albino leaf mutant was observed by EC 625693 of 200 ppm treatment.

Plate IX

4.1.10 Sterile head

SCG 62 of 300 ppm treatment exposed the sterile heads.

Plate X

4.1.11 Tall mutant

Tall mutant was manifested in EC 625693 of 200 ppm treatment.

Plate XI

4.2 Mean performance

The mean performance of mutant plants among treatments and between treatments along with control for ten attributes is depicted in Appendix II and Appendix III, respectively with their mean, standard error, critical difference at 5%.

4.2.1 Days to 50% flowering

The mean values for days to 50% flowering among all mutant plants ranged from 54.50 (100 ppm of EC 625693) to 72.50 (300 ppm of EC 625693) with mean of 63.59. The mean values for control, 100 ppm, 200 ppm and 300 ppm ranged from 67.00 to 70.50, 54.50 to 70.50, 55.50 to 67.00, 62.00 to 72.50 in EC 625693 with mean of 68.37, 62.10, 62.79 and 65.17; 60.50 to 67.00, 57.50 to 67.00, 57.50 to 66 and 59 to 64.00 in EC 318761 with mean of 63.96, 62.11, 63.2 and 62.47; 61.50 to 65.00, 60.00 to 65, 61.00 to 66.50 and 61.00 to 66.00 in SCG 62 with mean of 63.79, 62.94, 62.75 and 63.41, respectively.

The mean values for days to 50% flowering of treatments varied from 62.10 to 68.37 with grand mean of 63.60. It was observed that days to 50% flowering were reduced in all mutagenic treatments. Maximum reduction was recorded in treatment 100 ppm of EC 625693 (62.10) followed by 100 ppm of EC 318761 (62.11) and 300 ppm of EC 318761 (62.47). In general, it was observed that there were wide variations among mutant plants for days to 50% flowering as compared to control.

4.2.2 Days to maturity

The mean values for days to maturity in all mutant plants varied from 77.00 (200 ppm of EC 625693) to 96.00 (300 ppm of SCG 62) with mean of 92.01. The mean values for control, 100 ppm, 200 ppm and 300 ppm ranged from 89.00 to 93.50, 86.00 to 90.50, 77.00 to 94.00 and 82.00 to 93.50 in EC 625693 with mean of 91.58, 88.63, 89.00 and 91.06; 92.50 to 97.00, 91.00 to 94.00, 88.50 to 94.50 and 91.00 to 94.50 in EC 318761 with mean of 94.17,

91.94, 91.68 and 93.05;92.00 to 95.00, 92.00 to 95.50, 93.00 to 94.50 and 90.0 to 96.00 in SCG 62 with mean of 93.75, 92.61, 93.25 and 93.50, respectively.

The mean values for days to maturity of treatments varied from 88.63 to 94.16 with grand mean of 92.02. Maximum duration of crop was reduced in 100 ppm of EC 625692 (88.63) followed by 200 ppm of EC 625693 (89.00) and 300 ppm of EC 625693 (91.06). In general, it was observed that there was decrease in duration of crop to harvest in all treated population as compared to control.

4.2.3 Plant height (cm)

The mean values for plant height among all mutant plants ranged from 107.50 (100 ppm of EC 625693) to 210.00 (300 ppm of EC 625693) with mean of 162.50. The mean values for control, 100 ppm, 200 ppm, 300 ppm ranged from 130.00 to 160.80, 107.5.00 to 167.00, 125.50 to 196.00 and 127.00 to 210.00 in EC 625693 with mean of 150.94, 146.18, 149.58 and 162.82; 154.50 to 197.00, 142.50 to 178.00, 158.50 to 189.50 and 142.50 to 202.50 in EC 318761 with mean of 180.04, 167.66, 181.31 and 180.41; 157.50 to 166.50, 129.50 to 180.00, 138.50 to 176.00 and 120.00 to 195.50 in SCG 62 with mean of 161.17, 147.44, 156.08 and 166.33, respectively.

The mean values for plant height of treatments varied from 146.18 to 181.31. It was observed that plant height was reduced in all treatments except in 300 ppm of all three mutant confectionary sunflower genotypes and 200 ppm of EC 318761. Maximum reduction was recorded in treatment 100 ppm of EC 625693 (146.18) followed by 100 ppm of SCG 62 (147.44) and 200 ppm of EC 625693 (149.58). In general, it was observed that there was a wide variation among mutant plants for plant height as compared to control.

4.2.4 Head diameter (cm)

The mean values for head diameter in all mutant plants varied from 9.85 (control of EC 625693) to 25.25 (100 ppm of EC 625693) with mean

of 16.31. The mean values for control, 100 ppm, 200 ppm, 300 ppm ranged from 9.85 to 19.25, 14.25 to 25.25, 13.50 to 22.00 and 11.50 to 24.50 in EC 625693 with mean of 15.72, 18.88, 16.79 and 16.54; 14.00 to 17.85, 16.60 to 20.35, 14.70 to 16.30 and 10.45 to 17.55 in EC 318761 with mean of 16.56, 18.66, 15.57 and 14.36; 14.95 to 18.25, 10.70 to 19.00, 13.20 to 18.90 and 7.70 to 18.55 in SCG 62 with mean values of 16.60, 16.36, 15.80 and 13.92, respectively.

The mean values for head diameter of treatments varied from 13.92 to 18.88 with grand mean of 16.31. It was observed that head diameter was increased in all treatments except in SCG 62 and 300 ppm of EC 318761. Significant increase in head diameters were observed in 100 ppm of EC 625693 (18.88) followed by 100 ppm of EC 318761 (18.66) and 200 ppm of EC 625693 (16.79). In general, it was observed that head diameter showed wide variations among mutant plants as compared to control.

4.2.5 Seed Filling (%)

The mean values for the seed filling (%) in all mutant plants varied from 18.74 (300 ppm of EC 625693) to 95.47 (control of SCG 62) with mean of 58.30. The mean values for control, 100 ppm, 200 ppm, 300 ppm ranged from 47.15 to 81.70, 30.88 to 89.91, 43.39 to 84.06 and 18.74 to 71.51 in EC 625693 with mean of 60.24, 66.86, 60.88 and 46.05; 61.35 to 75.35, 29.78 to 59.27, 25.82 to 52.74 and 23.58 to 45.04 in EC 318761 with mean of 68.85, 40.36, 38.74 and 34.56; 55.60 to 95.47, 44.02 to 80.88, 47.07 to 82.58 and 47.86 to 94.1 in SCG 62 with mean of 80.42, 66.06, 67.58 and 69.07, respectively.

The mean values for seed filling (%) of treatments varied from 34.56 to 80.42 with grand mean of 58.30. However, significant increase in seed filling (%) was observed in EC 625693 of 100 ppm. It was observed that increased dose of sodium azide adversely effects on seed filling (%).

4.2.6 Hull content (%)

The mean values for hull content among all mutant plants varied

from 31.50 (300 ppm of EC 625693) to 52.50 (200 ppm of EC 625693) with mean of 42.22. The mean values for control, 100 ppm, 200 ppm, 300 ppm ranged from 36.25 to 50.30, 35.00 to 50, 37.50 to 52.50 and 31.5 to 47 in EC 625693 with mean of 43.32, 44.10, 45.00 and 40.15; 42.00 to 46.50,40.50 to 43.50, 40.00 to 44.50 and 41.00 to 45.50 in EC 318761 with mean of 44.58, 42.44, 42.09 and 42.64; 39.50 to 43.00, 37.00 to 41.00, 38.50 to 42.50, 40.50 to 43.50 in SCG 62 with mean of 41.00, 39.22, 39.91 and 42.55, respectively.

The mean values for hull content of treatments varied from 39.22 to 45.00 with grand mean of 42.23. It was observed that hull content was reduced in all treatments except 100 and 200 ppm of EC 625693 and 300 ppm of SCG 62. Maximum decrease in hull content was observed in 100 ppm of SCG 62. In general, it was also observed that hull content was decreased in all mutagenic treatments.

4.2.7 100 grain weight (gm)

The mean performance for 100 grain weight in all treatments revealed that, it varied from 5.80 (200 ppm of SCG 62) to 11.65 (300 ppm of EC 625693) with mean of 8.05. The mean performance for control, 100 ppm, 200 ppm, 300 ppm ranged from 6.65 to 9.10, 6.75 to 9.50, 6.50 to 9.35 and 7.70 to 11.65 in EC 625693 with mean of 7.82, 8.08, 8.18 and 9.55; 8.15 to 10.25, 8.50 to 10.90, 9.45 to 7.65 and 8.70 to 11.4 in EC 318761 with mean of 9.66, 9.75, 8.80 and 9.61; 5.85 to 6.85, 5.90 to 6.91, 5.80 to 6.57 and 5.86 to 6.42 in SCG 62 with mean of 6.27, 6.44, 6.32 and 6.16, respectively.

The mean values for 100 grain weight of treatments varied from 6.16 to 9.75 with grand mean of 8.05. Significant high 100 grain weight was recorded in 100 ppm of EC 318761 (9.75). In general, it was observed that increase in dose of mutagen directly proportional to increase in 100 grain weight.

4.2.8 Oil content (%)

The mean performance for oil content in all treatments revealed that the range was varied from 25.97 to 32.04 with grand mean of 29.31. In

general, it was observed that there was a significant difference among treatments for oil content. The treatments, 100 ppm of SCG 62 (32.04), 200 ppm of SCG 62 (31.95) and 100 ppm of EC 625693 (31.02) recorded the superior oil content.

4.2.9 Sugar content (%)

The mean performance for sugar content in all treatments revealed that the range was varied from 1.40 to 1.96 with grand mean of 1.65. In general, it was observed that increase in dose of mutagen resulted in increase in sugar content except in 300 ppm of EC 625693. The treatments 200 ppm of SCG 62 (1.96), 100 ppm of EC 318761 (1.86) and 200 ppm of SCG 62 (1.84) recorded the superior sugar content (%) over its respective controls.

4.2.10 Seed yield per plant (gm)

The mean values for seed yield per plant in all the mutant plants ranged from 12.11 (300 ppm of EC 625693) to 36.2 (100 ppm of SCG 62) with mean of 23.45. The mean values for control, 100 ppm, 200 ppm, 300 ppm ranged from 22.90 to 29.05, 17.74 to 33.98, 14.24 to 36.15 and 12.11 to 36.82 in EC 625693 with mean of 26.24, 27.79, 23.30 and 22.81; 20.70 to 28.15, 21.05 to 31.40, 12.50 to 27.15 and 12.27 to 18.75 in EC 318761 with mean of 24.83, 25.34, 19.24 and 16.30; 18.8 to 33.65, 16.40 to 36.20, 12.55 to 28.05 and 12.80 to 24.55 in SCG 62 with mean of 25.92, 25.10, 22.10 and 21.46, respectively.

The mean values for seed yield per plant in treatments varied from 16.3 to 27.79 gram with grand mean of 23.45. In general, it was observed that with increased dose of mutagenic treatments decreased the seed yield per plant but in 100 ppm of two genotypes except in SCG 62 showed significant increase as compared to their respective control.

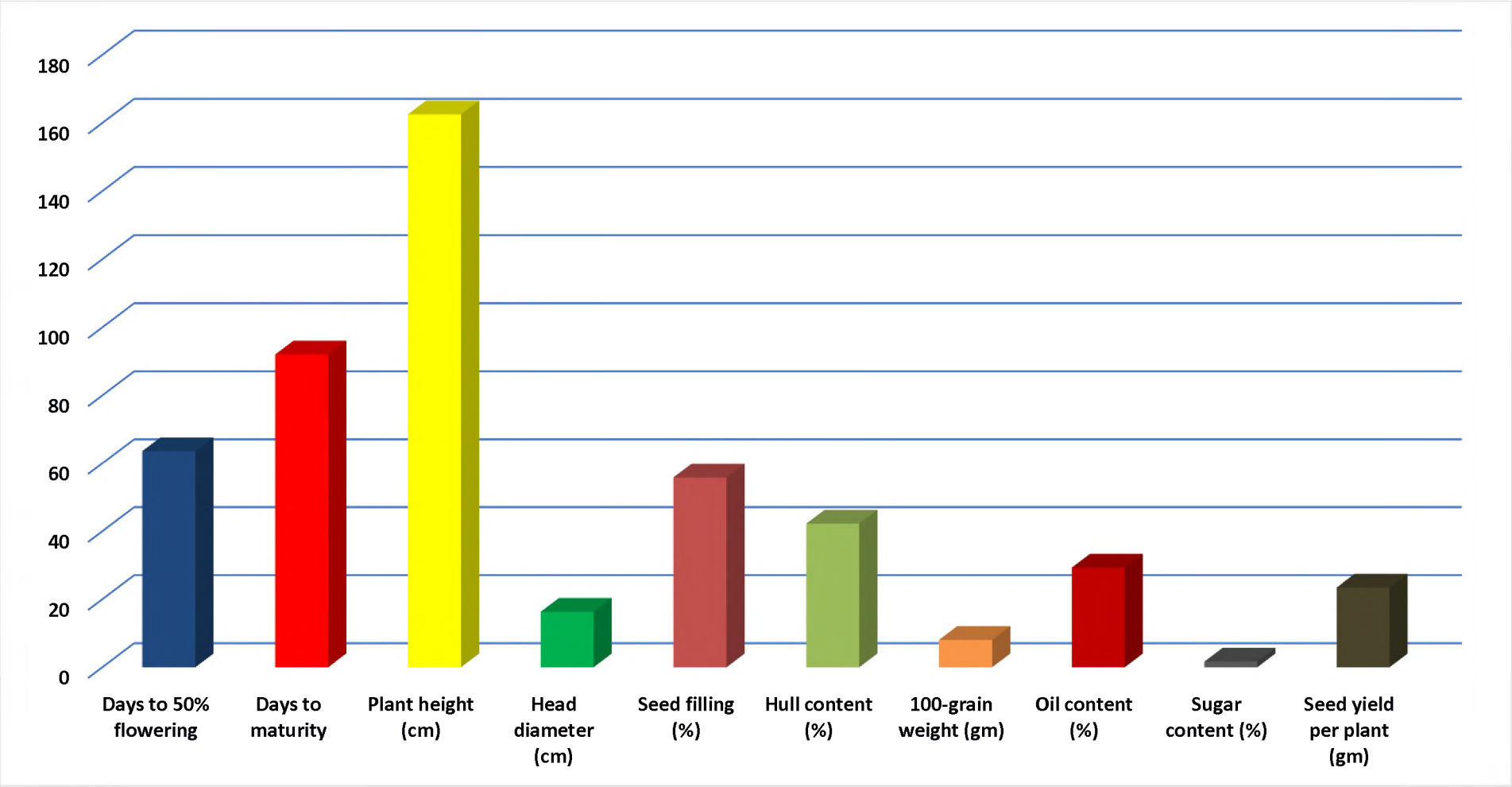

Fig.1: Mean performance between treatments for yield and yield contributing characters in M_2 generation of confectionary Sunflower.

4.3 Analysis of variance

The numerical data collected on quantitative characters were statistically analyzed and the Analysis of Variance (Table 1 and Table 2) showed highly significant differences among the mutant plants for all traits studied.

4.4. Genetic parameters

The genetic parameters estimated as range, mean, genotypic coefficient of variation, phenotypic coefficient of variation, heritability, genetic advance and expected genetic advance as per cent of mean for yield and yield contributing characters among and between treatments are depicted in (Table 3 and Table 4). The results are presented as follows.

4.4.1 Days to 50 % flowering

The variations for days to 50 % flowering revealed that there was low to wide range of variation among treatments. The highest range of variation observed in 100 ppm of EC 625693 (54.50 to 70.50) followed by 200 ppm of EC 625693 (55.00 to 67.00). The mean of days to 50 % flowering showed a negative shift. There was a significant difference over the control indicating reduction in days to 50 % flowering due to mutagenic treatment. The high genotypic and phenotypic coefficients of variations were recorded by 100 ppm (5.38, 8.12) and 200 ppm (4.91, 6.65) of EC 625693 and 100 ppm (4.41, 5.91) and 200 ppm (3.30, 4.41) of EC 318761, respectively. The remaining treatments showed medium to low genotypic and phenotypic variation for days to 50% flowering. The high heritability coupled with high genetic advance as per cent of mean was recorded by 200 ppm followed by high heritability 100 ppm and 300 ppm of SCG 62. The medium heritability coupled with high genetic advance was recorded by 100 ppm and 200 ppm of EC 625693 and EC 318761. Where as, 300 ppm of EC 625693 and EC 318761 exhibited medium heritability with low genetic advance as per cent of mean. Between the treatments low genotypic (2.63 %) and phenotypic coefficients (2.82 %) of variation was recorded for days to 50 % flowering, indicating that there was narrow range of variability. The heritability observed for

Table 1: Analysis of variance among mutant plants for yield and yield contributing characters in M_2 generation of confectionary sunflower.

Sr. No	Source of variation/ characters	Genotype name	Concentration/ dose	Mean sum of square's					
				D.F	Replication	D.F	Treatment	D.F	Error
1.	Days to 50% flowering	EC 625693	Control	1	0.37	11	5.19*	11	1.65
			100 ppm	1	2.70	14	36.58*	14	14.27
			200 ppm	1	18.37	11	26.95*	11	7.92
			300 ppm	1	1.39	22	11.62*	22	4.71
		EC 318761	Control	1	0.04	11	5.68*	11	1.86
			100 ppm	1	14.22	8	20.97*	8	5.97
			200 ppm	1	2.91	10	12.14*	10	3.41
			300 ppm	1	0.47	16	5.15**	16	1.47
		SCG 62	Control	1	1.04	11	2.04**	11	0.40
			100 ppm	1	0.50	8	5.18*	8	0.87
			200 ppm	1	4.08	5	7.75*	5	1.08
			300 ppm	1	4.08	5	6.28*	5	1.08
2.	Days to maturity	EC 625693	Control	1	0.67	11	2.71*	11	0.85
			100 ppm	1	0.83	14	4.10*	14	1.48
			200 ppm	1	0.17	11	59.64***	11	6.89
			300 ppm	1	1.06	22	10.01*	22	3.79
		EC 318761	Control	1	4.17	11	3.57*	11	1.26
			100 ppm	1	0.05	8	1.43**	8	0.18
			200 ppm	1	7.68	10	8.53*	10	1.78
			300 ppm	1	1.06	16	2.18*	16	0.87
		SCG 62	Control	1	2.67	11	2.59*	11	0.85
			100 ppm	1	0.05	8	2.85*	8	0.680
			200 ppm	1	0.08	5	0.75*	5	0.08
			300 ppm	1	0.33	5	10.20*	5	1.13

*,** Significant at 5 and 1 per cent level, respectively.

Continued…

Table 1: Analysis of variance among mutant plants for yield and yield contributing characters in M_2 generation of confectionary sunflower.

Sr. No	Source of variation/ characters	Genotype name	Concentration/ dose	Mean sum of square's					
				D.F	Replication	D.F	Treatment	D.F	Error
3.	Plant height (cm)	EC 625693	Control	1	12.47	11	277.95*	11	93.30
			100 ppm	1	508.41	14	812.00*	14	279.62
			200 ppm	1	416.67	11	1104.53*	11	385.03
			300 ppm	1	83.56	22	1098.12*	22	523.56
		EC 318761	Control	1	1.04	11	490.40*	11	130.50
			100 ppm	1	107.55	8	219.62*	8	37.18
			200 ppm	1	0.41	10	126.13**	10	11.31
			300 ppm	1	7.53	16	543.08*	16	229.09
		SCG 62	Control	1	13.50	11	18.85*	11	6.59
			100 ppm	1	3.55	8	459.93*	8	66.43
			200 ppm	1	10.08	5	422.28*	5	69.88
			300 ppm	1	645.33	5	1387.73*	5	274.53
4.	Head diameter (cm)	EC 625693	Control	1	0.01	11	14.66**	11	1.95
			100 ppm	1	25.95	14	26.42*	14	10.43
			200 ppm	1	5.04	11	15.95*	11	5.22
			300 ppm	1	40.19	22	25.72*	22	12.06
		EC 318761	Control	1	0.02	11	4.97*	11	1.35
			100 ppm	1	0.43	8	2.99*	8	0.86
			200 ppm	1	0.02	10	0.53*	10	0.17
			300 ppm	1	0.49	16	7.38*	16	3.14
		SCG 62	Control	1	0.00	11	1.86*	11	0.56
			100 ppm	1	2.57	8	16.34*	8	4.40
			200 ppm	1	0.01	5	8.52*	5	1.50
			300 ppm	1	1.84	5	27.19*	5	5.35

*,** Significant at 5 and 1 per cent level, respectively.

Continued…

Table 1: Analysis of variance among mutant plants for yield and yield contributing characters in M_2 generation of confectionary sunflower.

Sr. No	Source of variation/ characters	Genotype name	Concentration/ dose	Mean sum of square's					
				D.F	Replication	D.F	Treatment	D.F	Error
5.	Seed filling (%)	EC 625693	Control	1	8.60	11	189.32*	11	66.61
			100 ppm	1	126.20	14	473.29***	14	28.04
			200 ppm	1	5.35	11	263.31*	11	62.53
			300 ppm	1	16.57	22	476.19*	22	191.43
		EC 318761	Control	1	10.15	11	82.32*	11	28.37
			100 ppm	1	2.07	8	178.94***	8	17.15
			200 ppm	1	1.64	10	149.89**	10	31.76
			300 ppm	1	5.26	16	89.05*	16	31.45
		SCG 62	Control	1	270.21	11	417.46**	11	82.93
			100 ppm	1	5.13	8	292.77**	8	44.22
			200 ppm	1	51.83	5	296.05*	5	29.13
			300 ppm	1	226.81	5	466.23*	5	84.95
6.	Hull content (%)	EC 625693	Control	1	16.19	11	40.61*	11	12.20
			100 ppm	1	0.83	14	41.16*	14	16.12
			200 ppm	1	13.50	11	58.54*	11	19.86
			300 ppm	1	1.06	22	20.61**	22	6.97
		EC 318761	Control	1	0.17	11	4.62*	11	1.17
			100 ppm	1	0.22	8	2.93*	8	0.85
			200 ppm	1	1.64	10	4.28*	10	0.94
			300 ppm	1	1.88	16	2.73*	16	1.13
		SCG 62	Control	1	1.50	11	2.73*	11	0.95
			100 ppm	1	0.22	8	6.89*	8	1.72
			200 ppm	1	0.08	5	5.08*	5	0.68
			300 ppm	1	0.08	5	4.55*	5	0.68

*,** Significant at 5 and 1 per cent level, respectively.

Continued…

Table 1: Analysis of variance among mutant plants for yield and yield contributing characters in M_2 generation of confectionary sunflower.

Sr. No	Source of variation/ characters	Genotype name	Concentration/ dose	Mean sum of square's					
				D.F	Replication	D.F	Treatment	D.F	Error
7.	100 grain weight (gm)	EC 625693	Control	1	1.18	11	1.19*	11	0.29
			100 ppm	1	2.10	14	1.27*	14	0.51
			200 ppm	1	1..55	11	1.04*	11	0.34
			300 ppm	1	2.92	22	2.38**	22	0.79
		EC 318761	Control	1	0.60	11	0.75*	11	0.22
			100 ppm	1	0.29	8	1.41*	8	0.35
			200 ppm	1	0.52	10	0.51*	10	0.16
			300 ppm	1	0.95	16	1.01**	16	0.22
		SCG 62	Control	1	0.07	11	0.19*	11	0.06
			100 ppm	1	0.00	8	0.21*	8	0.05
			200 ppm	1	0.09	5	0.16*	5	0.02
			300 ppm	1	0.05	5	0.11*	5	0.02
8.	Seed yield per plant (gm)	EC 625693	Control	1	0.12	11	11.45*	11	3.95
			100 ppm	1	27.74	14	34.53*	14	11.20
			200 ppm	1	17.20	11	60.55*	11	21.02
			300 ppm	1	0.47	22	76.73*	22	32.36
		EC 318761	Control	1	4.59	11	9.12*	11	3.03
			100 ppm	1	9.10	8	16.27*	8	4.57
			200 ppm	1	0.04	10	30.95*	10	9.28
			300 ppm	1	11.70	16	6.75*	16	2.61
		SCG 62	Control	1	3.45	11	38.00*	11	9.76
			100 ppm	1	0.80	8	87.17*	8	24.54
			200 ppm	1	39.97	5	58.03*	5	10.07
			300 ppm	1	3.20	5	39.70*	5	5.65

*,** Significant at 5 and 1 per cent level, respectively.

Table 2: Analysis of variance between treatments for yield and yield contributing characters in M_2 generation of confectionary sunflower.

Sr. No.	Source of variation/ characters	Mean sum of square's		
		Replication	Treatment	Error
	D.F	1	11	11
1.	Days to 50% flowering	0.42	6.02***	0.43
2.	Days to maturity	0.02	6.27***	0.14
3.	Plant height (cm)	10.57	338.18***	16.94
4.	Head diameter (cm)	1.11	4.22***	0.31
5.	Seed filling (%)	9.82	464.94***	6.50
6.	Hull content (%)	0.06	6.98***	0.27
7.	100 grain weight (gm)	0.08	4.20***	0.06
8.	Oil content (%)	0.62	10.65***	0.86
9.	Sugar content (%)	0.01	0.08***	0.002
10.	Seed yield per plant (gm)	2.15	22.15***	0.98

*,** Significant at 5 and 1 per cent level, respectively.

Table 3: Estimates of range, mean, shift in mean, phenotypic and genotypic coefficient of variation, heritability and genetic advance among mutant plants for yield and yield contributing characters in M_2 generation of confectionary sunflower.

Sr. No.	Parameters	Genotype name	Concentration/ dose	Range	Mean ± S.E	Shift in mean	GCV (%)	PCV (%)	Heritability (B.S) (%)	Genetic advance	Genetic advance as % of mean
1.	Days to 50% flowering	EC 625693	Control	66.50-72.00	68.37±0.87		1.88	2.70	51.83	1.97	2.89
			100 ppm	54.50-70.50	62.10±2.58	-6.27	5.38	8.12	43.88	4.56	7.34
			200 ppm	55.50-67.00	62.79±1.90	-5.58	4.91	6.65	54.57	4.69	7.47
			300 ppm	62.00-72.50	65.17±1.50	-3.2	2.85	4.38	42.31	2.49	3.82
		EC 318761	Control	60.50-67.00	63.96±0.92		2.16	3.03	50.65	2.02	3.17
			100 ppm	57.50-67.00	62.11±1.63	-1.85	4.41	5.91	55.67	4.21	6.78
			200 ppm	57.50-66.00	63.27±1.24	-0.69	3.30	4.41	56.14	3.22	5.09
			300 ppm	59.00-64.00	62.47±0.83	-1.49	2.17	2.91	55.60	2.08	3.34
		SCG 62	Control	61.50-65.00	63.79±0.43		1.42	1.73	66.87	1.52	2.39
			100 ppm	60.00-65.00	62.94±0.62	-0.85	2.33	2.76	71.10	2.55	4.05
			200 ppm	61.00-65.50	62.75±0.67	-1.04	2.91	3.35	75.47	3.27	5.21
			300 ppm	61.00-66.00	63.41±0.67	-0.37	2.54	3.03	70.59	2.79	4.40
	C.D. (p=0.05)					1.45					
2.	Days to maturity	EC 625693	Control	89.00-93.50	91.58±0.62		1.05	1.46	52.34	1.44	1.57
			100 ppm	86.00-90.50	88.63±0.83	-2.95	1.29	1.88	47.10	1.62	1.83
			200 ppm	77.00-94.00	89.00±1.78	-2.58	5.71	6.48	79.28	9.42	10.58
			300 ppm	82.00-93.50	91.06±1.35	-0.52	1.94	2.88	45.06	2.44	2.68
		EC 318761	Control	92.50-97.00	94.17±0.76		1.14	1.65	47.96	1.53	1.63
			100 ppm	91.00-94.00	91.94±0.28	-2.23	0.86	0.98	77.59	1.43	1.56
			200 ppm	88.50-94.50	91.68±0.90	-2.49	2.00	2.48	65.43	3.06	3.34
			300 ppm	91.00-94.50	93.05±0.64	-1.11	0.87	1.33	42.89	1.09	1.17
		SCG 62	Control	92.00-95.00	93.75±0.62		0.99	1.40	50.66	1.37	1.46
			100 ppm	92.00-95.50	92.61±0.55	-1.14	1.12	1.43	61.42	1.68	1.81
			200 ppm	93.00-94.50	93.25±0.19	-0.5	0.62	0.69	80.00	1.06	1.14
			300 ppm	90.00-96.00	93.50±0.69	-0.25	2.28	2.55	80.00	3.92	4.19
	C.D. (p=0.05)					0.83					

Continued…

Table 3: Estimates of range, mean, shift in mean, phenotypic and genotypic coefficient of variation, heritability and genetic advance among mutant plants for yield and yield contributing characters in M_2 generation of confectionary sunflower.

Sr. No.	Parameters	Genotype name	Concentration/ dose	Range	Mean ± S.E	Shift in mean	GCV (%)	PCV (%)	Heritability (B.S) (%)	Genetic advance	Genetic advance as % of mean
3.	Plant height (cm)	EC 625693	Control	128.5-165.0	150.94±6.54		6.36	9.02	49.74	13.96	9.25
			100 ppm	107.5-191.0	146.18±11.42	-4.76	11.16	15.98	48.77	23.47	16.06
			200 ppm	125.5-196.0	149.58±13.28	-1.36	12.68	18.24	48.30	27.15	18.15
			300 ppm	127.0-210.0	162.82±15.82	+11.89	10.41	17.49	35.43	20.78	12.76
		EC 318761	Control	154.5-197.0	180.04±7.73		7.45	9.79	57.97	21.04	11.68
			100 ppm	142.5-178.0	167.67±4.06	-12.37	5.70	6.76	71.04	16.58	9.89
			200 ppm	158.5-189.5	181.31±2.27	+1.28	4.18	4.57	83.54	14.27	7.87
			300 ppm	142.5-202.5	180.41±10.38	+0.37	6.94	10.89	40.66	16.46	9.12
		SCG 62	Control	157.5-166.5	161.17±1.74		1.54	2.21	48.18	3.54	2.20
			100 ppm	129.5-180.0	147.44±5.43	-13.73	9.51	11.00	74.76	24.98	16.94
			200 ppm	138.5-176.0	156.08±5.40	-5.09	8.50	10.05	71.60	23.14	14.82
			300 ppm	120.0-195.5	166.33±10.69	+5.16	14.18	17.33	66.97	39.77	23.91
	C.D. (p=0.05)					9.05					
4.	Head diameter (cm)	EC 625693	Control	9.85-19.25	15.72±0.94		16.03	18.33	76.55	4.54	28.90
			100 ppm	13.50-25.25	18.88±2.20	+3.16	14.98	22.74	43.38	3.84	20.32
			200 ppm	13.50-22.00	16.79±1.54	+1.07	13.79	19.38	50.66	3.39	20.22
			300 ppm	11.50-24.50	16.54±2.40	+0.82	15.79	26.27	36.16	3.24	19.57
		EC 318761	Control	14.00-18.50	16.56±0.79		8.13	10.73	57.32	2.10	12.67
			100 ppm	16.60-20.35	18.66±0.62	+2.11	5.53	7.43	55.34	1.58	8.47
			200 ppm	14.70-16.30	15.57±0.28	-0.99	2.72	3.82	50.80	0.62	3.99
			300 ppm	10.45-17.55	14.36±1.22	-2.2	10.13	15.98	40.23	1.90	13.24
		SCG 62	Control	14.95-18.25	16.60±0.51		4.84	6.62	53.39	1.21	7.29
			100 ppm	10.70-19.00	16.36±1.40	-0.24	14.93	19.68	57.58	3.82	23.34
			200 ppm	13.20-18.90	15.80±0.79	-0.81	11.86	14.17	70.01	3.23	20.44
			300 ppm	7.70-18.55	13.92±1.49	-2.69	23.73	28.97	67.11	5.58	40.05
	C.D. (p=0.05)					1.23					

Continued…

Table 3: Estimates of range, mean, shift in mean, phenotypic and genotypic coefficient of variation, heritability and genetic advance among mutant plants for yield and yield contributing characters in M_2 generation of confectionary sunflower.

Sr. No.	Parameters	Genotype name	Concentration/ dose	Range	Mean ± S.E	Shift in mean	GCV (%)	PCV (%)	Heritability (B.S) (%)	Genetic advance	Genetic advance as % of mean
5.	Seed filling (%)	EC 625693	Control	47.15-81.70	60.24±5.52		13.00	18.78	47.95	11.17	18.55
			100 ppm	30.88-89.91	66.86±3.61	+6.62	22.32	23.68	88.81	28.91	43.32
			200 ppm	43.39-84.06	60.88±5.35	+0.64	16.45	20.96	61.62	16.20	26.61
			300 ppm	18.74-71.51	46.05±9.57	-14.19	25.91	39.68	42.65	16.05	34.86
		EC 318761	Control	61.35-75.35	68.85±3.61		13.37	19.15	48.74	7.47	19.30
			100 ppm	29.78-59.27	40.36±2.76	-28.49	22.28	24.53	82.51	16.83	41.69
			200 ppm	25.82-52.74	38.74±3.80	-30.11	19.83	24.60	65.03	12.77	32.95
			300 ppm	23.58-45.04	34.56±3.85	-34.29	15.53	22.46	47.80	7.64	22.11
		SCG 62	Control	55.60-95.47	80.42±6.16		16.08	19.67	66.85	21.78	27.09
			100 ppm	44.02-80.89	66.06±4.43	-14.35	16.87	19.65	73.75	19.72	29.85
			200 ppm	47.07-82.58	67.58±3.48	-12.83	17.09	18.87	82.08	21.56	31.90
			300 ppm	47.86-94.10	69.07±5.95	-11.35	19.99	24.03	69.17	23.66	34.25
	C.D. (p=0.05)					5.61					
6.	Hull content (%)	EC 625693	Control	36.25-50.30	43.32±2.36		8.70	11.86	53.80	5.69	13.15
			100 ppm	35.00-50.00	44.10±2.74	+0.78	7.86	12.02	42.71	4.67	10.58
			200 ppm	37.50-52.50	45.00±3.02	+1.68	9.77	13.91	49.33	6.36	14.14
			300 ppm	31.50-47.00	40.15±1.83	-3.17	6.50	9.25	49.43	3.78	9.42
		EC 318761	Control	42.60-46.50	44.58±0.73		2.95	3.81	59.69	2.09	4.69
			100 ppm	40.50-44.00	42.44±0.61	-2.14	2.40	3.24	55.15	1.56	3.68
			200 ppm	40.00-44.50	42.09±0.65	-2.49	3.07	3.84	64.11	2.13	5.07
			300 ppm	41.00-45.50	42.65±0.73	-1.93	2.10	3.26	41.11	1.19	2.78
		SCG 62	Control	39.50-43.00	41.00±0.66		2.30	3.31	48.15	1.34	3.28
			100 ppm	37.00-43.00	39.22±0.87	-1.78	4.10	5.29	60.00	2.56	6.54
			200 ppm	38.50-42.50	39.91±0.53	-1.08	3.71	4.25	76.30	2.67	6.69
			300 ppm	40.50-44.00	42.25±0.53	+2.15	3.29	3.83	73.89	2.46	5.83
	C.D. (p=0.05)					1.15					

Continued…

Table 3: Estimates of range, mean, shift in mean, phenotypic and genotypic coefficient of variation, heritability and genetic advance among mutant plants for yield and yield contributing characters in M_2 generation of confectionary sunflower.

Sr. No.	Parameters	Genotype name	Concentration/ dose	Range	Mean ± S.E	Shift in mean	GCV (%)	PCV (%)	Heritability (B.S) (%)	Genetic advance	Genetic advance as % of mean
7.	100 grain weight (gm)	EC 625693	Control	6.65-9.10	7.82±0.36		8.58	11.00	60.76	1.07	13.77
			100 ppm	6.75-9.50	8.08±0.49	+0.26	7.63	11.65	42.91	0.83	10.30
			200 ppm	6.50-9.35	8.18±0.39	+0.36	7.22	10.14	50.76	0.87	10.60
			300 ppm	7.70-11.65	9.55±0.61	+1.73	9.34	13.19	50.14	1.30	13.62
		EC 318761	Control	8.15-10.25	9.66±0.31		5.36	7.17	55.89	0.80	8.26
			100 ppm	8.50-10.90	9.75±0.39	+0.09	7.47	9.64	60.07	1.16	11.93
			200 ppm	7.65-9.45	8.80±0.27	-0.86	4.73	6.55	52.08	0.62	7.03
			300 ppm	8.70-11.40	9.61±0.32	-0.05	6.52	8.16	63.84	1.03	10.73
		SCG 62	Control	5.85-6.85	6.27±0.17		4.00	5.63	50.75	0.36	5.88
			100 ppm	5.90-6.91	6.44±0.15	+0.17	4.47	5.65	62.67	0.47	7.29
			200 ppm	5.80-6.57	6.32±0.10	+0.06	4.05	4.77	72.14	0.45	7.09
			300 ppm	5.86-6.42	6.16±0.09	-0.11	3.52	4.18	71.06	0.38	6.11
	C.D. (p=0.05)					0.53					
8.	Seed yield per plant (gm)	EC 625693	Control	22.90-30.80	26.24±1.34		7.38	10.58	48.72	2.78	10.61
			100 ppm	17.74-33.98	27.79±2.28	+1.55	12.29	17.20	51.05	5.03	18.09
			200 ppm	14.24-36.15	23.30±3.10	-2.94	19.07	27.40	48.46	6.37	27.35
			300 ppm	12.11-36.82	22.82±3.93	-3.42	20.64	32.37	40.68	6.19	27.12
		EC 318761	Control	20.70-28.15	24.83±1.18		7.03	9.92	50.16	2.55	10.25
			100 ppm	21.05-31.40	25.34±1.43	+0.5	9.54	12.74	56.10	3.73	14.72
			200 ppm	12.50-27.15	19.25±2.05	-5.59	17.10	23.30	53.84	4.97	25.84
			300 ppm	12.27-18.75	16.30±1.11	-8.54	8.82	13.27	44.24	1.97	12.09
		SCG 62	Control	18.80-33.65	26.92±2.11		13.96	18.15	59.12	5.95	22.11
			100 ppm	16.40-36.20	25.10±3.30	-1.82	22.29	29.77	56.06	8.63	34.38
			200 ppm	12.55-28.05	22.11±2.04	-4.81	22.15	26.39	70.43	8.47	38.29
			300 ppm	12.80-24.55	21.47±1.53	-5.45	19.22	22.18	75.09	7.37	34.31
	C.D. (p=0.05)					2.18					

this trait was high (86.60 %) with low genetic advance as per cent of mean (5.04 %), which indicates that simple selection would be effective for the trait improvement.

4.4.2 Days to maturity

The variations for days to maturity among the treatments revealed that there was narrow range of variation in all treatments including control. The negative shift in mean values were observed in all treatments, however maximum reduction were found in 100 ppm of all genotypes except EC 318761. The magnitudes of GCV (5.71 %), PCV (6.48 %), heritability (79.28 %), genetic advance as per cent of mean (10.58) were higher in 200 ppm of EC 625693 followed by 300 ppm (SCG 62) and 200 ppm (EC 318761). However the treatment, 100 ppm (EC 318761) and 200 ppm (SCG 62) recorded low GCV, PCV and genetic advance as per cent of mean but high heritability. The remaining treatments showed low GCV and PCV and low genetic advance as per cent of mean with medium heritability.

Days to maturity exhibited low GCV and PCV coupled with high heritability and low genetic advance as per cent of mean between the treatments.

4.4.3 Plant height (cm)

The variations for plant height among the treatments revealed that the highest range of variation observed in 100 ppm of EC 625693 (107.5 to 191.0) followed by 300 ppm of EC 625693 (127.0 to 210.0) and 300 ppm of SCG 62 (120.0 to 195.5). Negative shift in mean of plant was observed in all treatments except in 300 ppm in all genotypes over the control indicates that the dose of mutagen reduces the plant height. The phenotypic coefficient of variations were higher than the genotypic coefficient of variations for all treatments. The highest genotypic coefficient of variation and phenotypic coefficient of variation, heritability and genetic advance as per cent of mean were exhibited by 100 ppm (9.51, 11.00, 74.76 and 16.94), 200 ppm (8.50, 10.05, 71.60 and 14.82) and 300 ppm (14.18, 17.33, 66.97 and 23.91) of SCG

62, respectively. Where as EC 625693 of treatments 100 ppm (11.13, 15.98, 48.77 and 16.06), 200 ppm (12.68, 18.24, 48.30 and 18.5) and 300 ppm (10.41, 17.49, 35.43 and 12.18) recorded high GCV and PCV, medium heritability and high genetic advance as per cent of mean, as compared to control, respectively. The treatments, 100 ppm and 200 ppm of EC 318761 exhibited medium PCV and GCV, high heritability coupled with medium genetic advance as per cent of mean.

The genotypic (7.80 %) and phenotypic (8.20 %) coefficient of variation estimates between treatments observed for this traits were moderate, indicating there was a scope for improvement this trait. High heritability (90.50 %) coupled with medium genetic advance as per cent of mean (15.28 %) was recorded for plant height which was indicating that, there was preponderance of additive gene action in controlling this trait. Hence, direct selection of the characters would be effective in improving the seed yield per plant.

4.4.4 Head diameter (cm)

In the present investigation, the highest variability for head diameter among treatments were observed in 300 ppm of EC 625693, 100 ppm of EC 625693, 300 ppm of SCG 62 and 200 ppm of EC 625693. The mean values showed positive shift in EC 625693, where as negative shift in SCG 62. There was a significant difference among the treatments as compared to control. The phenotypic coefficient of variation was higher than the genotypic coefficient of variation including control. The treatments 200 ppm (23.73, 28.97, 67.11 and 40.05), 100 ppm (14.93, 19.68, 57.58 and 23.34) and 200 ppm (11.86, 14.17, 70.01 and 20.044) of SCG 62 exhibited highest GCV, PCV, heritability coupled with high genetic advance as per cent of mean, respectively, where as treatments, 300 ppm (15.79, 26.27, 36.16 and 19.57), 100 ppm (14.98, 22.74, 43.38 and 20.32) and 200 ppm (13.79, 19.38, 50.66 and 20.22) of EC 625693 recorded high GCV and PCV, moderate heritability coupled with high genetic advance as per cent of mean, respectively. The treatments of 300 ppm (10.13, 15.98, 40.23 and 13.23), 100 ppm (5.53, 7.43,

55.34 and 8.47) revealed low GCV, PCV, moderate heritability coupled with low genetic advance as per cent of mean.

Moderate genotypic (8.57 %) and phenotypic (9.23%) coefficients of variation was observed for head diameter between treatments. The heritability estimates for this character was high (86.10 %) with medium genetic advance as per cent of mean (16.40 %) indicating the preponderance of additive gene action. Hence for this trait selection was efficient.

4.4.5 Seed filling (%)

The variations for seed filling percentage among the treatments revealed that the highest range of variations were observed in 100 ppm of EC 625693 (30.88 to 89.91) followed by 300 ppm of EC 625693 (18.74 to 71.51), 300 ppm of SCG 62 (47.86 to 94.10), 200 ppm of EC 625693 (43.39 to 84.06) and control of SCG 62 (55.60 to 95.47). The mean values showed shift in negative direction with increased dose of treatments. The phenotypic coefficient of variations was higher than genotypic coefficient of variations in all treatments including control. The highest genotypic coefficient of variation, phenotypic coefficient of variation, heritability and genetic advance as per cent of mean were exhibited by 100 ppm of EC 625693 (22.32, 23.68, 88.81 and 43.32) and 100 ppm of EC 318761 (22.28, 24.53, 82.51 and 41.69), respectively. Where as 300 ppm of EC 625693 (25.91, 39.68, 42.65 and 34.86) showed high GCV, PCV, medium heritability and high genetic advance as per cent of mean. All remaining treatments shows medium GCV, PCV with moderate heritability and genetic advance as per cent of mean except control as they showed moderate values.

Between the treatments, seed filling percentage exhibited high values for genotypic (27.13 %) and phenotypic (27.51 %) coefficient of variation. High heritability (97.24 %) and high genetic advance as per cent of mean (55.1 %) indicating the predominance of additive gene effect, can be taken as unit for selection.

Table 4: Estimates of range, mean, shift in mean, phenotypic and genotypic coefficient of variation, heritability and genetic advance between treatments for yield and yield contributing characters in M_2 generation of confectionary sunflower.

Sr. No.	Parameters	Range	Mean	GCV (%)	PCV (%)	Heritability (B.S) (%)	Genetic advance	Genetic advance as % of mean
1.	Days to 50% flowering	62.10-68.37	63.50	2.63	2.82	86.60	3.20	5.04
2.	Days to maturity	88.63-94.16	92.02	1.91	1.95	95.60	3.53	3.83
3.	Plant height (cm)	146.18-181.31	162.50	7.80	8.20	90.50	24.83	15.28
4.	Head diameter (cm)	13.92-18.89	16.31	8.57	9.23	86.10	2.67	16.40
5.	Seed filling (%)	34.56-80.42	58.30	27.13	27.51	97.24	30.75	55.10
6.	Hull content (%)	39.22-45.00	42.23	4.34	4.51	92.52	3.63	8.60
7.	100-grain weight (gm)	6.16-9.75	8.05	17.88	18.12	97.31	2.92	36.32
8.	Oil content (%)	25.13-32.04	29.31	7.55	8.18	85.06	4.20	14.34
9.	Sugar content (%)	1.40-1.95	1.65	12.00	12.30	94.60	0.40	23.97
10.	Seed yield per plant (gm)	16.30-27.79	23.45	13.88	14.50	91.50	6.41	27.33

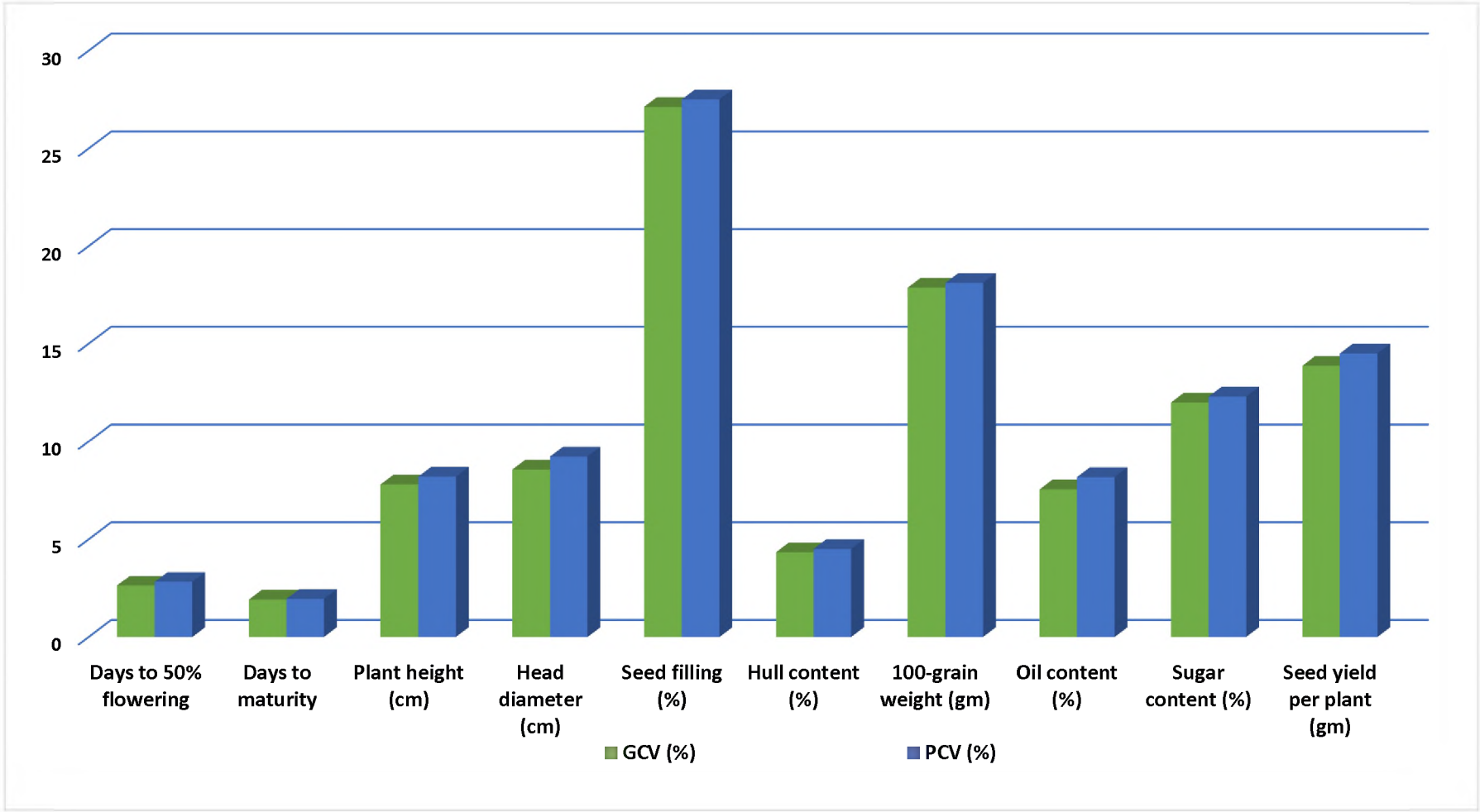

Fig. 2: Genotypic and phenotypic coefficient of variances.

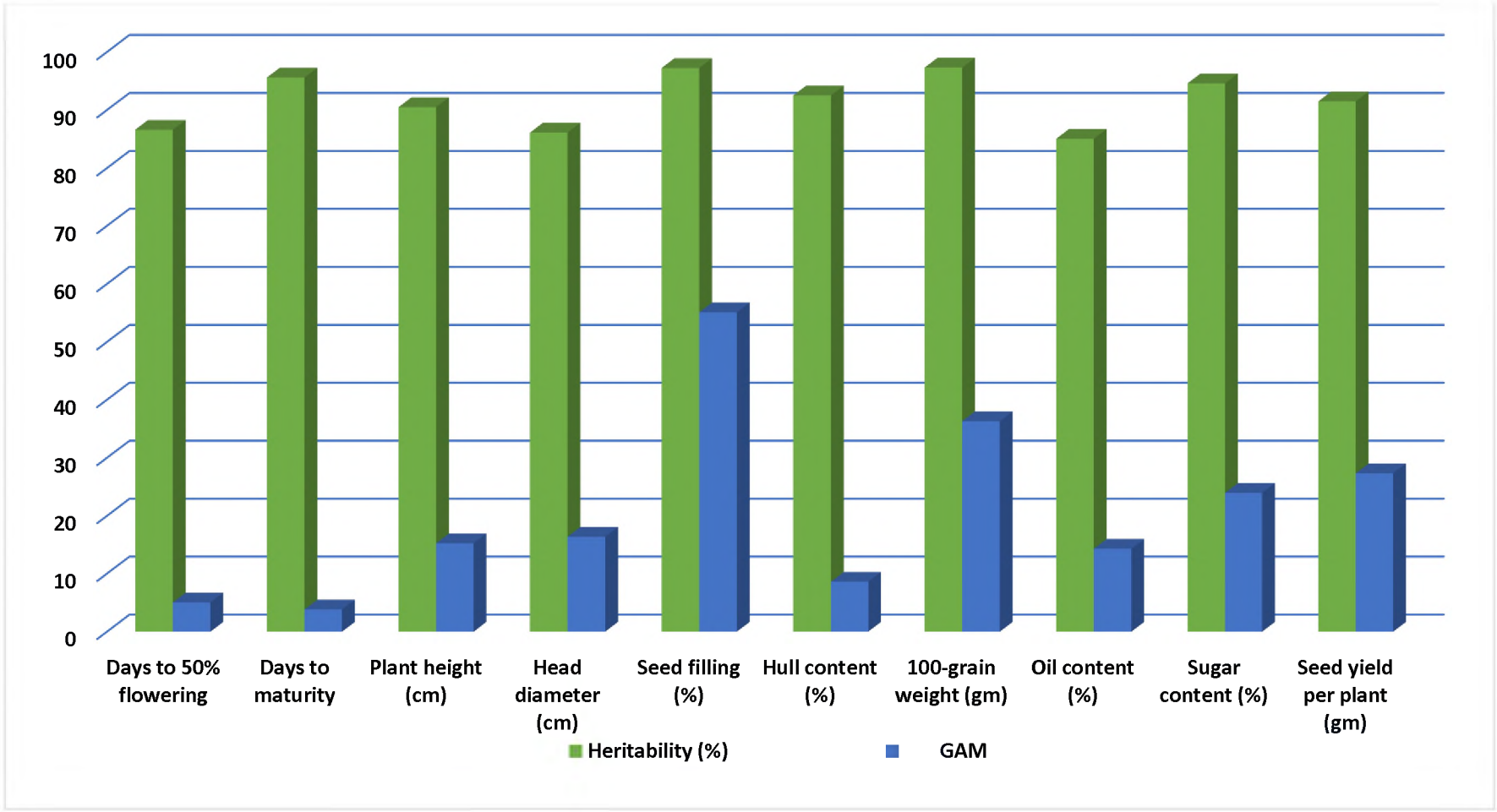

Fig. 3: Heritability, Genetic advance as per cent of mean.

4.4.6 Hull content (%)

Among the treatments highest range of variations were observed for 300 ppm followed by 100 ppm, 200 ppm and control of EC 625693. Most of the treatments showed negative shift in 100 ppm, 200 ppm of EC 625693 and 300 ppm of SCG 62 over the control. The phenotypic coefficients of variations were higher than the genotypic coefficients of variation. The highest genotypic and phenotypic coefficient of variation were recorded by 200 ppm (9.77, 13.91), control (8.70, 11.86) and 100 ppm (7.86, 12.02) of EC 625693. All other treatments showed medium to low genotypic and phenotypic coefficient of variation for hull content. The high heritability coupled with moderate genetic advance as per cent of mean was recorded by 200 ppm followed by 300 ppm and 100 ppm of SCG 62. The moderate heritability coupled with high genetic advance as per cent of mean was recorded by 200 ppm, 100 ppm and control of EC 625693, where as, remaining treatments showed low to moderate heritability with low genetic advance as per cent of mean.

The genotypic (4.34 %) and phenotypic (4.51 %) coefficients of variation estimates observed for this trait were low between treatments. The heritability observed for this character was high (92.52 %) with low genetic advance as per cent of mean (8.60 %). Hence, there was a good scope of improvement for this trait through simple selection.

4.4.7 100 grain weight (gm)

The variations for 100-grain weight revealed that there was narrow range of variations among the treatments. The mean values showed positive shift in mean of all treatments except, 200 ppm of EC 318761 and 300 ppm of SCG 62. In EC 625693 the shift in mean was increases with increasing the dose of mutagen. The highest genotypic coefficient of variation and phenotypic coefficient of variation, heritability and genetic advance as per cent of mean were revealed by 100 ppm (7.47, 9.64, 60.07 and 11.93) of EC 625693, 300 ppm (9.34, 13.18, 50.14 and 13.62) and 100 ppm (7.63, 11.65, 42.91 and

10.30) of EC 625693, respectively. Where as SCG 62 of treatments 100 ppm (4.47, 5.65, 62.67 and 7.29), 200 ppm (4.05, 4.77, 72.14 and 7.09) and 300 ppm (3.52, 4.18, 71.06 and 6.11) recorded moderate GCV, PCV, heritability and genetic advance as per cent of mean.

High genotypic (17.88 %) and phenotypic (18.12 %) coefficients of variation between treatments were recorded for 100 grain weight. High heritability (97.31 %) coupled with high genetic advance as per cent of mean (36.32 %) observed for this trait, indicating the presence of additive gene action. Hence, selection for this trait was effective.

4.4.8 Oil content (%)

Moderate genotypic (7.55 %) and phenotypic (8.18%) coefficients of variations was recorded for oil content between treatments. High heritability (85.06 %) and moderate genetic advance as per cent of mean (14.34 %) indicating that simple selection would be effective for this trait improvement.

4.4.9 Sugar content (%)

Between treatments, high genotypic (12.00 %) and phenotypic (12.30 %) coefficients of variations was recorded for sugar content. High heritability (94.06%) coupled with high genetic advance as per cent of mean (23.97 %) seen in this trait, indicating the preponderance of additive gene action. Hence, selection for this trait was effective.

4.4.10 Seed yield per plant (gm)

Among the treatments the highest variation were observed in the treatments, 300 ppm of EC 625693, 200 ppm of EC 625693, 100 ppm of SCG 62, 100 ppm of EC 625693 and 200 ppm of SCG 62. The negative shift in mean was increased with increasing in dose, except 100 ppm of EC 625693 and EC 318761. While, highest negative shift in mean were seen in 300 ppm of EC 625693, EC 318761 and SCG 62, respectively. The phenotypic coefficient of variation was higher than genotypic coefficient of variation. The high genotypic and phenotypic coefficient of variations were observed in 100 ppm (22.29,

29.77) and 200 ppm (22.15, 26.39) of SCG 62 and 300 ppm (20.64, 32.37) of EC 625693, respectively. Low values of GCV and PCV were seen in control of EC 625693 and EC 318761. Where as, SCG 62 control exhibits moderate GCV and PCV (13.96, 18.15). The high heritability coupled with high genetic advance as per cent of mean was recorded by 200 ppm (70.43, 38.29) and 300 ppm (75.09, 34.31) of SCG 62, respectively. Moderate heritability with high genetic advance as per cent of mean was observed in 100 ppm (56.06, 34.38) of SCG 62, 200 ppm (48.46, 27.35) and 300 ppm (40.68, 27.12) of EC 625693, repectively. The remaining treatments showed medium heritability and low to moderate genetic advance as per cent of mean.

Seed yield per plant exhibited high values for genotypic (13.88 %) and phenotypic (14.50 %) coefficient of variations between treatments. High heritability (91.50 %) and high genetic advance as per cent of mean (27.33 %) indicating the preponderance of additive gene action and selection was effective for this trait.

The presence of genetic variability in a given crop species for the trait improvement is of paramount importance for the success of any crop improvement programme. Heritability coupled with genetic advance as per cent of mean was important selection parameters. Genotypic coefficient of variation coupled with high heritability estimates gives good scope for the amount of genetic advance to be expected by phenotypic selection. Heritability coupled with genetic advance is more useful in estimating the gain under selection with heritability estimates alone. Therefore, high heritability predicts the effective selection of a particular trait. The characters with high heritability coupled with high genetic advance as per cent of mean indicate the presence of additive gene action and selection gives best results for particular traits.

DISCUSSION

CHAPTER V

DISCUSSION

The results of the present investigation done by giving sodium azide treatments of 100 ppm, 200 ppm, 300 ppm along with control to three confectionary sunflower genotypes, EC 625693, EC 318761 and SCG 62 for isolation of viable mutants and variability parameters are briefly discussed below.

5.1 Morphological mutants

The spectrum of morphological mutants were wide. Ten different types of morphological mutants were isolated.

5.1.1 An extremely early dwarf mutant

An extreme early dwarf mutant was characterized by reduction in plant height, flowering and head size. This mutant was observed in EC 625693 of 100 ppm. Similar result was noticed by Lyakh *et al.* (2005) and Jambhulkar (2002).

5.1.2 Mosaic leaf

An interrupted green mosaic leaf mutant was reported in SCG 62 of 100 ppm treatment. This result are in agreement with Kumar and Ratnam (2010b).

5.1.3 Rosette leaf

SCG 62 of 300 ppm treatment showed rosette leaf mutant with reduction in internodal length. Such mutant was noticed by Kumar and Ratnam (2010b).

5.1.4 Curved ray florets

Soroka and Lyakh (2009) noticed the curved and increase in length of ray florets. It was observed in EC 318761 of 200 ppm treatment.

5.1.5 Dwarf mutant

Dwarf mutant was isolated in 200 ppm of EC 625693 and EC 318761. Such mutants were earlier reported by Lyakh *et al.* (2005) and Kumar and Ratnam (2010b).

5.1.6 Basal stem bifurcation

Stem bifurcation was earlier revealed by Kumar and Ratnam (2010b). SCG 62 of 100 ppm and 200 ppm and EC 318761 of 300 ppm showed such mutants.

5.1.7 Variegated leaf

Variegated mutant was seen in 300 ppm of EC 625693. Similar mutant was earlier reported by Mostafa (2011).

5.1.8 Corrugated leaf

Lyakh *et al.* (2005) also isolated corrugated leaf mutant characterized by alternating parallel grooves and ridges on upper leaves and it was observed in EC 625693 of 300 ppm.

5.1.9 Patchy albino

EC 625693 of 200 ppm treatment displayed the patchy albino mutant and similar mutant was earlier reported by Kumar and Ratnam(2010 b).

5.1.10 Sterile head

Soroka and Lyakh (2009) revealed the sterile heads and it was obtained in 300 ppm of SCG 62.

5.1.11 Tall mutant

Tall mutant was manifested by Cvejic *et al.* (2011). It was observed in EC 625693 of 200 ppm treatment.

5.2 Mean performance

The analysis of variance revealed highly significant differences among treatments and between treatments (Appendix II and III) indicating the

presence of considerable amount of genetic variability in M_2 generation for days to 50 % flowering, days to maturity, plant height, head diameter, seed filling percentage, hull content, test weight, oil content, sugar content and seed yield per plant. The mutagenic treatments had significant effect on variability for all characters which creates ample scope for selection of agronomically desirable mutant plants. Similar results were reported by Giriraj *et al.* (2004), Jagadeesan *et al.* (2008), Encheva *et al.* (2008), Cvejic *et al.* (2011) and Cvejic *et al.* (2015).

In the M_2 generation of mutant plants of all three confectionary sunflower genotypes among treatments and between treatments, there were significant differences in the mean values for all the characters studied. Among the treatments (Appendix II), 100 ppm of EC 625693 recorded highest seed yield per plant, head diameter and seed filling percentage. Where as 100 ppm of EC 318761 exhibited highest sugar content and 100 grain weight. Highest oil content was recorded by 100 ppm of SCG 62.

The highest mean values between treatments were recorded by 100 ppm of EC 625693 for seed yield per plant and head diameter; 300 ppm of SCG 62 for sugar content and seed filling percentage; 100 ppm of EC 318761 for 100 grain weight and 100 ppm of SCG 62 for oil content (Appendix II).

The mutant plants in all three genotypes showed wide range of variations for plant height, seed filling percentage, seed yield per plant, head diameter and 100 grain weight (Table 3). Similar results in mutant populations of sunflower were reported by Martinez and Gimenez (1988) for plant height and head diameter; Christov (1996) for plant height, head diameter and 100 grain weight and Sanjeev and Giriraj (1997) and Giriraj *et al.* (2004) for test weight.

Induced mutagenesis leads negative shift in mean values for days to 50% flowering and days to maturity in all three genotypes with all treatments of sodium azide. Similar observations have been also observed in SCG 62 for head diameter, seed filling percentage and seed yield per plant in

EC 318761 for hull content. The results are in accordance with earlier findings of Lofgren and Ramaraje (1982), Martinez and Gimenez (1988) and Cvejic *et al.* (2015) in sunflower; Roychowdhury *et al.* (2012) in mungbean and Gunasekaran and Pavadai (2015) in groundnut for days to 50% flowering and Jagadeesan *et al.* (2008) in sunflower; Khan and Goyal (2009) in mungbean and Kulmi and Mogali (2016) in linseed for days to maturity. Head diameter and test weight of EC 625693 in all three treatments showed positive shift in mean values as compared to their control. The results are in conformity with findings of Martinez and Gimenez (1988), Jagadeesan *et al.* (2008) and Cvejic *et al.* (2015) for head diameter and Lofgren and Ramaraje (1982), Giriraj *et al.* (1990), Christov (1996), Sanjeev and Giriraj (1997), Giriraj *et al.* (2004) and Jagadeesan *et al.* (2008) for test weight.

In both the genotypes. EC 625693 and EC 318761, 100 ppm treatment of sodium azide increased mean values for head diameter, test weight and seed yield per plant. However, the remaining treatments showed either positive or negative shift in mean values as compared to their respective control for most of the traits. Vranceanu and Iuoras (1990) and Cvejic *et al.* (2015) in sunflower, Wani and Anis (2008) in chickpea, Pavadai *et al.* (2010) in soybean and Roychowdhury *et al.* (2012) in mungbean reported positive shift in mean value for seed yield per plant in mutant population.

5.3 Genetic parameters

For the adoption of suitable breeding programmes, the agreement of heritable and non heritable components of the variability present in among treatments and of treatments is indispensable. The heritable components are assessed with phenotypic coefficient of variation, genotypic coefficient of variation, heritability coupled with genetic advance as per cent of mean. The heritability coupled with genetic advance as per cent of mean estimates showed a better picture for phenotypic selection of mutant plants for crop improvement.

Wide differences between the genotypic coefficient of variation and phenotypic coefficient of variation implied that the population was highly affected due to environmental effects and vice versa.

5.3.1 Coefficient of variability

The estimates of genetic parameters among the mutant populations of treatment (Table 3) revealed that there were wider variations in phenotypic and genotypic coefficient of variations for most of the characters indicting influence of environment in expressing these traits. In general, a relative comparison of the magnitude of genotypic coefficient of variation and phenotypic coefficient of variation for different traits revealed that induced genotypic and phenotypic coefficient of variations were higher over the control for most of the characters.

The phenotypic coefficient of variations and genotypic coefficient of variations (Table 4) were higher for seed filling percentage, 100 grain weight, seed yield per plant and sugar content indicating that greater amount of variability was induced in mutant populations. Similar findings were also reported by Reddy and Reddy (2006) in sunflower for seed filling percentage; Ashok *et al.* (2000), Sujatha *et al.* (2002), Reddy and Reddy (2006), Sridhar *et al.* (2006) and Kalukhe *et al.* (2010) in sunflower and Badigannavar and Murthy (2007) in groundnut for 100 grain weight. Chikkadevaiah *et al.* (1998), Ashok *et al.* (2000), Reddy and Reddy (2006), Sridhar *et al.* (2006), Khan *et al.* (2007), Kalukhe *et al.* (2010), Kumar *et al.* (2011), Makane *et al.* (2011), Hassan *et al.* (2012), Neelima *et al.* (2012) and Natikar *et al.* (2013) in sunflower for seed yield per plant.

The traits like plant height, head diameter and oil content exhibited moderate PCV and GCV parameters. Kumar *et al.* (2011), Hassan *et al.* (2012), Natikar *et al.* (2013), Sudrik *et al.* (2014) and Rani (2016) in sunflower reported similar findings for head diameter and oil content. Whereas, for plant height the results are in conformity with findings of Ashok *et al.* (2000), Sujatha *et al.* (2002), Seneviratne *et al.* (2004), Reddy and Reddy

(2006), Neelima *et al.* (2012) in sunflower and Veeramani *et al.* (2005) and Hiremath *et al.* (2011) in groundnut.

Low genotypic coefficient of variation and phenotypic coefficient of variation values were exhibited for days to 50 % flowering, days to maturity and hull content indicating the narrow range of variability for these characters and restricts the phenotypic selection. These results are in harmony with the Kalukhe *et al.* (2010) and Sudrik *et al.* (2014) in sunflower for days to 50% flowering and days to maturity and hull content. Whereas, for days to 50 % flowering and days to maturity results are conformity with Seneviratne *et al.* (2004), Reddy and Reddy (2006), Khan *et al.* (2007), Makane *et al.* (2011), Natikar *et al.* (2013), Rani (2016) in sunflower and Kulmi *et al.* (2017) in linseed.

5.3.2 Heritability and genetic advance as percent of mean

Heritability in broad sense is the ratio of genotypic variance to the phenotypic variance. Heritability value coupled with genetic advance as percent of mean showed a better approach for selection. Therefore, the characters with high heritability is of better selection at phenotypic level and breeding values together with low genetic advance was an indication of non-additive gene action.

In the current study, in general, high to medium heritability with genetic advance as percent of mean estimates were observed in mutant populations for most of the characters. The values of heritability increased and different from traits to traits (Table 3). Increased heritability and genetic advance as percent of mean due to the mutagens were reported by Veeramani *et al.* (2005).

High heritability coupled with high genetic advance as percent of mean was observed in SCG 62 for seed yield per plant, seed filling percentage, head diameter and plant height indicating importance of additive gene action and improvement of these traits could be made possible by simple selection. However, the high to medium heritability with low genetic advance as percent

of means were reported for most of the characters in all three genotypes except seed filling percentage and seed yield per plant.

High heritability coupled with high genetic advance as percent of means were noticed for seed filling percentage followed by 100 grain weight, seed yield per plant, sugar content (Table 4) indicated the presence of additive gene action and improvement of above characters could be made possible by simple phenotypic selection in mutant populations. Ashok *et al.* (2000), Reddy and Reddy (2006), Arshad *et al.* (2010), Sudrik *et al.* (2014) in sunflower; Wani and Anis (2008) in chickpea and Arulbalachandran and Mullainathan (2009) in blackgram reported similar findings for 100 grain weight, seed yield per plant. Reddy and Reddy (2006) and Rani (2016) in sunflower for seed filling percentage and Wadikar *et al.* (2018) for sugar content in sweet sorghum showed similar contrary results.

Head diameter, plant height and oil content showed high heritability with moderate genetic advance as percent of mean which suggested that improvement of these characters is not possible by simple phenotypic selection. These findings confirm the results of Jagadeesan *et al.* (2008), Kalukhe *et al.* (2010) and Rani (2016) for head diameter in sunflower. Where as for plant height the similar findings are reported by Seneviratne *et al.* (2004) , Jagadeesan *et al.* (2008), Kalukhe *et al.* (2010) and Rani (2016). Seneviratne *et al.* (2004), Arshad *et al.* (2010), Kalukhe *et al.* (2010), Makane *et al.* (2011), Hassan *et al.* (2012) and Rani (2016) also reported similar findings for oil content in sunflower.

High heritability with low genetic advance as percent of mean reported for hull content, days to 50% flowering and days to maturity indicating of non-additive interaction. Similar reports in sunflower have been published by Sujatha *et al.*(2002), Giriraj *et al.* (2004), Seneviratne *et al.*(2004) ,Makane *et al.* (2011), Kumar *et al.* (2011), Neelima *et al.* (2012), Mahmoud (2012) and Rani (2016). Khan and Goyal (2009) in mungbean and Kulmi *et al.* (2017) in linseed for days to maturity.

SUMMARY AND CONCLUSION

CHAPTER VI

SUMMARY AND CONCLUSION

The present research entitled "Mutation studies in confectionary type of sunflower (*Helianthus annuus* L.)" was conducted for isolation of visible mutants, variability parameters, heritability and genetic advance as percent of mean. Four treatments *viz.,* 100 ppm, 200 ppm and 300 ppm including control for three confectionary sunflower genotypes, EC 625693, EC 318761 and SCG 62 were evaluated at Experimental Farm, Department of Agricultural Botany, College of Agriculture, Latur during *kharif*, 2017. The observations were recorded for ten characters *viz.,* days to 50 % flowering, days to maturity, plant height, head diameter, seed filling percentage, hull content, test weight, oil content, sugar content and seed yield per plant.

The analysis of variance revealed significant differences in mutant populations among and between treatments for all ten characters indicating the variability in mutant population material was mainly due to genotypic variance.

The mean performance recorded an adverse effects on yield and yield contributing traits of sodium azide treatments. A completely negative shift in mean value was observed for days to 50 % flowering and days to maturity for all mutant treatments. Whereas, SCG 62 mutant populations showed negative shift in mean values for head diameter and seed yield per plant and EC 318761 for hull content. A positive shift in mean values for head diameter, seed filling percentage, 100 grain weight and seed yield per plant was occurred in treated population. The treatments 100 ppm had high mean value for yield and yield contributing characters like head diameter, seed filling percentage, 100 grain weight and seed yield per plant, except for SCG 62 mutant population where it showed mostly negative response for sodium azide treatments.

The estimates of GCV, PCV, heritability and genetic advance as percent of mean among treatments were maximum in treatments, 300 ppm for

head diameter, seed filling percentage and seed yield per plant. Whereas 100 ppm for 100 grain weight and 200 ppm for seed yield per plant also exhibited high estimates of GCV, PCV, heritability and genetic advance as percent of mean in all three genotypes.

In general, the seed filling percentage, 100 grain weight, sugar content, seed yield per plant showed high GCV, PCV, heritability and genetic advance as percent of mean in treatments. Hence, selection for these characters enhances genetic improvement.

Conclusion:

- The mutagenic populations showed wide range of variations for all the ten characters.
- The highest genetic variation in M_2 generation plant occurred in 300 ppm for head diameter, seed filling percentage and seed yield per plant and 100 ppm for 100 seed weight and seed yield per plant.
- The characters with high GCV, PCV, heritability and genetic advance as percent of mean such as seed filling percentage, 100 grain weight and seed yield per plant would be better responded for selection.
- The mutagenic populations widens the genetic base of plants as they helpful in gene pool, hence it would be utilized in hybridization programmes for improvement of characters.

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ABSTRACT

"Mutation studies in confectionary type of sunflower (*Helianthus annuus* L.)"

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ABSTRACT

The present investigation was conducted with three confectionary sunflower genotypes *viz.,* EC 625693, EC 318761 and SCG 62. Which were treated with mutagen sodium azide (NaN_3) at concentration of 100 ppm, 200 ppm and 300 ppm. The experimental materials were grown in randomized block design with two replications at the Experimental farm, Department of Agricultural Botany, College of Agriculture, Latur. The main objective of this experiment was to elucidate information mainly on the genetic variability among and between treatments for yield and yield contributing characters. The observations were recorded for ten characters *viz.,* days to 50 % flowering, days to maturity, plant height, head diameter, seed filling percentage, hull content, 100 grain weight, oil content, sugar content and seed yield per plant. Substantial amount of genetic variability have been induced for all the characters, which was indicated by significant difference among and between treatments.

Among the treatments 100 ppm of EC 625693 recorded highest seed yield per plant, head diameter and seed filling percentage. Where as 100 ppm of EC 318761 exhibited highest sugar content and 100 grain weight. Highest oil content was recorded by 100 ppm of SCG 62. The treatment 100 ppm of EC 625693 for seed yield per plant and head diameter; 300 ppm of SCG 62 for sugar content and seed filling percentage; 100 ppm of EC 318761 for 100 grain weight and 100 ppm of SCG 62 for oil content exhibited highest mean values between treatments.

A negative shift in mean values were observed for days to 50 % flowering, days to maturity and plant height in treated population, However the

positive shift in mean was revealed in head diameter, seed filling percentage, hull content, 100 grain weight, oil content, seed yield per plant, sugar content.

The estimates of GCV, PCV, heritability and genetic advance as percent of mean among treatments were maximum in treatment, 300 ppm for head diameter, seed filling percentage and seed yield per plant, 100 ppm for 100 grain weight and 200 ppm for seed yield per plant. Meanwhile, seed filling percentage, 100 grain weight, sugar content and seed yield per plant exhibited highest genetic parameters between treatments.

APPENDICES

Appendix I: Meteorological data recorded at Latur for the period of experiment during *rabi* 2016-17 and *kharif* 2017.

Month and year	Standard Week	Temperature (°C)		Relative Humidity (%)		Rainfall (mm)	Rainy Days
		Max.	Min.	AM	PM		
December 2016	49	28.1	12.1	44	54	0.0	-
	50	27.9	11.6	43	54	0.0	-
	51	29.1	11.8	34	47	0.0	-
	52	28.5	10.9	35	42	0.0	-
January 2017	1	27.9	12.4	72	29	0.0	-
	2	26.5	11.6	82	38	0.0	-
	3	27.8	14.1	83	37	0.0	-
	4	29.3	15.5	76	32	0.0	-
Febraury 2017	5	31.0	15.6	69	25	0.0	-
	6	31.6	16.5	67	27	0.0	-
	7	31.0	16.9	66	25	0.0	-
	8	34.5	16.9	50	17	0.0	-
March 2017	9	34.1	17.6	44	15	0.0	-
	10	33.7	17.9	25	22	0.0	-
	11	32.5	17.9	36	41	15.0	1
	12	35.9	20.1	21	23	0.0	-
July 2017	27	31.9	23.2	88	54	75.0	2
	28	30.6	23.2	90	59	0.0	-
	29	28.6	22.5	97	55	34.0	3
	30	30.0	22.0	95	56	3.0	1
August 2017	31	30.9	22.3	92	51	0.0	0
	32	29.7	22.8	94	54	4.0	1
	33	28.3	22.1	98	58	21.0	2
	34	27.9	21.5	100	74	184.0	4
September 2017	35	29.5	21.7	97	74	22.0	2
	36	30.9	22.8	98	61	4.0	1
	37	30.3	22.0	100	70	137.0	4
	38	28.6	21.6	100	74	20.0	2
	39	31.7	21.9	100	82	8.0	1
October 2017	40	31.5	21.6	90	74	0.0	0
	41	30.5	22.6	100	66	101.0	3
	42	31.2	21.1	89	52	13.0	1
	43	31.3	19.6	88	41	0.0	-

A.M - Anti meridian, P.M – Post meridian

Appendix II: Mean performance among mutant plants for yield and yield contributing characters in M_2 generation of confectionary sunflower.

Mutant Plants	Days to 50% Flowering	Days to maturity	Plant height (cm)	Head diameter (cm)	Seed filling (%)	Hull content (%)	100 grain weight (gm)	Seed yield per plant (gm)
EC-625693 : Control								
1	68.00	92.50	160.80	17.55	49.37	43.85	6.85	24.65
2	67.00	90.50	159.20	17.65	57.69	37.25	7.85	26.95
3	70.50	93.50	150.55	15.90	69.99	45.10	8.43	26.00
4	68.00	91.50	130.00	16.75	47.15	50.30	8.75	24.20
5	66.50	89.00	165.00	10.95	56.86	43.76	7.45	29.05
6	69.50	92.50	142.95	15.50	64.79	42.91	6.85	27.05
7	69.00	92.50	154.00	17.10	64.50	36.84	7.98	27.95
8	67.00	91.00	147.30	9.85	81.70	48.26	9.10	25.00
9	68.00	92.00	128.50	16.25	59.01	46.80	6.65	23.10
10	72.00	91.50	158.10	15.50	64.79	42.91	7.95	27.20
11	67.50	91.50	157.85	19.25	49.87	36.25	7.70	30.80
12	67.50	91.00	157.10	16.45	57.135	45.60	8.30	22.90
Mean	**68.37**	**91.58**	**150.94**	**15.72**	**60.24**	**43.32**	**7.82**	**26.24**
S.E ±	**0.91**	**0.65**	**6.83**	**0.99**	**5.77**	**2.47**	**0.38**	**1.40**
C.D at 5%	**2.82**	**2.03**	**21.26**	**3.07**	**17.96**	**7.69**	**1.19**	**4.37**
EC-625693 : 100 ppm								
1	66.00	90.50	134.75	19.40	70.760	44.00	7.45	29.30
2	54.50	88.50	167.00	19.20	67.94	43.00	8.35	29.25
3	57.50	88.00	161.50	19.35	79.33	38.50	7.30	30.30
4	65.00	86.00	149.50	18.15	89.91	49.50	6.90	28.25
5	60.50	87.50	152.00	24.75	30.88	41.00	8.65	17.74
6	63.00	90.50	191.00	24.10	63.74	35.00	8.35	26.97
7	59.00	89.50	152.50	13.50	68.34	44.00	8.75	24.42
8	56.50	90.00	142.00	17.25	51.59	49.00	9.50	23.60
9	59.50	87.50	122.50	25.25	46.89	48.50	8.05	24.50
10	70.50	87.50	141.50	20.15	53.60	48.00	9.10	33.85
11	61.50	90.00	145.50	15.80	75.60	38.50	8.60	33.98
12	63.50	87.50	121.50	14.25	82.83	43.00	7.55	30.55
13	63.50	87.50	149.00	19.15	74.27	50.00	7.70	28.19
14	64.00	88.50	107.50	18.05	76.62	44.50	6.75	26.15
15	67.00	90.50	155.00	14.80	70.56	45.00	8.25	29.80
Mean	**62.10**	**88.63**	**146.18**	**18.88**	**66.86**	**44.10**	**8.08**	**27.79**
S.E ±	**2.67**	**0.86**	**11.82**	**2.28**	**3.74**	**2.84**	**0.50**	**2.36**
C.D at 5%	**8.10**	**2.60**	**35.86**	**6.93**	**11.36**	**8.61**	**1.52**	**7.17**

Continued…

Appendix II: Mean performance among mutant plants for yield and yield contributing characters in M_2 generation of confectionary sunflower.

Mutant Plants	Days to 50% Flowering	Days to maturity	Plant height (cm)	Head diameter (cm)	Seed filling (%)	Hull content (%)	100 grain weight (gm)	Seed yield per plant (gm)
EC-625693 : 200 ppm								
1	63.50	90.50	196.00	22.00	59.98	50.50	7.75	26.60
2	64.50	93.00	151.50	14.00	77.83	38.50	8.45	36.15
3	67.00	90.00	161.00	18.50	53.45	39.50	9.35	20.20
4	65.50	92.00	129.00	17.00	56.52	43.50	8.15	22.51
5	65.00	92.50	180.50	17.50	60.47	40.00	8.20	27.46
6	64.00	90.00	129.00	16.00	52.19	49.50	7.80	23.72
7	64.50	90.00	146.50	22.00	43.39	52.00	8.95	14.24
8	63.50	94.00	174.50	15.50	54.80	47.00	8.55	24.19
9	60.00	91.50	135.50	16.00	57.51	52.50	8.40	18.24
10	64.50	89.00	125.50	15.00	58.77	43.00	6.50	22.49
11	56.00	78.50	129.50	13.50	71.57	37.50	7.65	19.06
12	55.50	77.00	136.50	14.50	84.06	46.50	8.40	24.79
Mean	**62.79**	**89.00**	**149.58**	**16.79**	**60.88**	**45.00**	**8.18**	**23.30**
S.E ±	**1.99**	**1.86**	**13.87**	**1.62**	**5.59**	**3.15**	**0.41**	**3.24**
C.D at 5%	**6.19**	**5.78**	**43.19**	**5.03**	**17.40**	**9.80**	**1.28**	**10.09**
EC-625693 : 300 ppm								
1	72.00	92.50	202.00	15.00	55.95	39.50	10.20	21.93
2	64.50	92.50	207.00	16.50	37.72	37.50	10.25	21.82
3	64.50	91.00	127.00	20.00	46.34	39.50	10.40	28.38
4	64.00	82.00	148.00	20.00	35.20	31.50	9.60	21.42
5	72.50	92.50	184.00	16.50	71.51	40.00	9.60	36.82
6	65.00	91.00	153.00	12.00	24.84	37.50	9.30	15.50
7	65.00	90.50	210.00	12.00	29.57	47.00	10.05	12.11
8	64.50	91.00	160.00	14.00	40.84	38.50	10.65	19.77
9	65.00	91.00	181.50	16.50	38.29	38.50	11.65	20.27
10	66.50	92.00	146.00	14.00	62.89	43.00	8.65	22.50
11	63.50	91.00	158.00	20.50	40.69	42.50	11.40	31.09
12	65.00	90.50	180.50	17.50	24.07	38.00	10.45	16.10
13	65.50	91.00	151.00	12.00	34.38	35.50	10.30	15.28
14	65.00	91.00	171.00	13.50	69.91	40.50	9.40	30.56
15	64.00	93.00	172.50	21.00	71.24	43.00	10.15	32.25
16	65.50	93.50	147.00	24.50	39.19	43.00	8.45	24.53
17	64.00	92.00	147.00	11.50	63.17	42.00	8.75	19.32
18	65.00	92.00	158.50	20.00	57.70	40.00	9.05	28.26
19	64.00	92.50	153.50	20.00	49.42	40.50	7.70	26.56
20	64.50	92.50	130.50	12.50	57.27	45.00	8.75	20.55
21	63.00	90.00	154.00	19.00	18.74	39.50	9.45	16.25
22	64.50	89.50	128.50	15.50	44.95	41.00	7.70	22.30
23	62.00	90.00	174.50	16.50	45.13	40.50	7.80	21.16
Mean	**65.17**	**91.06**	**162.82**	**16.54**	**46.05**	**40.15**	**9.55**	**22.81**
S.E ±	**1.53**	**1.38**	**16.18**	**2.45**	**9.78**	**1.87**	**0.62**	**4.02**
C.D at 5%	**4.50**	**4.04**	**47.45**	**7.20**	**28.69**	**5.48**	**1.84**	**11.80**

Continued…

Appendix II: Mean performance among mutant plants for yield and yield contributing characters in M_2 generation of confectionary sunflower.

Mutant Plants	Days to 50% Flowering	Days to maturity	Plant height (cm)	Head diameter (cm)	Seed filling (%)	Hull content (%)	100 grain weight (gm)	Seed yield per plant (gm)
EC-318761 : Control								
1	67.00	97.00	187.50	17.20	68.85	46.00	10.25	25.05
2	64.00	93.00	155.50	14.95	65.36	46.00	9.95	25.30
3	63.50	93.50	197.00	14.95	65.38	43.50	9.70	28.15
4	62.00	94.00	174.50	17.50	65.36	45.00	9.75	23.35
5	63.50	93.50	169.00	14.15	73.56	42.00	8.15	23.65
6	64.00	94.50	196.50	17.50	69.85	45.50	9.90	20.70
7	65.00	92.50	197.00	18.50	63.5	43.50	9.70	28.15
8	60.50	93.50	174.50	17.50	65.32	45.00	9.75	24.95
9	66.00	96.50	172.50	17.60	63	46.50	10.05	23.70
10	64.50	93.50	185.50	14.00	61.35	42.00	8.70	26.65
11	63.50	94.50	154.50	17.05	65.35	44.50	10.10	25.15
12	64.00	94.00	196.50	17.85	75.35	45.50	9.90	23.25
Mean	**63.96**	**94.17**	**180.04**	**16.56**	**68.85**	**44.58**	**9.66**	**24.83**
S.E ±	**0.96**	**0.79**	**8.08**	**0.82**	**3.77**	**0.76**	**0.32**	**1.23**
C.D at 5%	**3.00**	**2.47**	**25.14**	**2.56**	**11.72**	**2.378**	**1.01**	**3.83**
EC-318761 : 100 ppm								
1	62.50	92.00	178.00	17.00	47.54	41.50	9.30	25.55
2	61.00	91.50	168.50	19.70	38.28	44.00	10.55	25.65
3	58.50	91.50	170.00	19.55	30.42	42.50	10.40	21.05
4	62.00	92.00	176.50	19.10	46.15	43.00	8.90	26.45
5	57.50	91.00	142.50	16.60	59.27	41.00	9.10	31.40
6	60.00	91.50	172.00	18.60	33.39	43.50	10.35	24.05
7	65.00	94.00	168.50	18.60	37.37	42.50	10.90	26.55
8	67.00	92.00	162.50	20.35	29.78	40.50	9.75	23.50
9	65.50	92.00	170.50	18.50	41.09	43.50	8.50	23.90
Mean	**62.11**	**91.94**	**167.66**	**18.66**	**40.36**	**42.44**	**9.75**	**25.34**
S.E ±	**1.73**	**0.30**	**4.31**	**0.65**	**2.93**	**0.65**	**0.42**	**1.51**
C.D at 5%	**5.63**	**0.98**	**14.06**	**2.14**	**9.55**	**2.12**	**1.37**	**4.93**
EC-318761 : 200 ppm								
1	64.00	92.00	182.50	16.05	36.15	43.00	8.60	17.55
2	65.00	89.50	184.50	16.30	47.13	42.00	8.50	21.50
3	63.00	88.50	181.00	15.70	52.74	44.00	8.70	27.15
4	57.50	89.00	186.00	14.80	43.40	44.50	9.30	21.85
5	63.50	93.00	189.50	15.30	27.65	43.00	9.30	14.75
6	60.50	92.50	158.50	15.95	42.90	41.50	8.90	20.75
7	65.50	94.50	183.00	15.85	25.82	41.00	9.45	18.02
8	66.00	93.50	182.50	15.55	35.04	42.00	8.95	16.95
9	63.50	90.00	182.00	15.90	38.80	42.00	8.95	19.90
10	65.00	92.50	183.50	15.20	46.44	40.00	8.50	20.80
11	62.50	93.50	181.50	14.70	30.10	40.00	7.65	12.50
Mean	**63.27**	**91.68**	**181.31**	**15.57**	**38.74**	**42.09**	**8.80**	**19.24**
S.E ±	**1.30**	**0.94**	**2.38**	**0.29**	**3.98**	**0.68**	**0.28**	**2.15**
C.D at 5%	**4.11**	**2.97**	**7.49**	**0.93**	**12.55**	**2.15**	**0.89**	**6.79**

Continued…

Appendix II: Mean performance among mutant plants for yield and yield contributing characters in M_2 generation of confectionary sunflower.

Mutant Plants	Days to 50% Flowering	Days to maturity	Plant height (cm)	Head diameter (cm)	Seed filling (%)	Hull content (%)	100 grain weight (gm)	Seed yield per plant (gm)
EC-318761 : 300 ppm								
1	63.50	93.00	182.50	16.55	26.29	42.50	9.20	13.05
2	64.00	93.00	190.50	12.20	43.91	42.50	8.70	18.75
3	64.00	93.50	179.50	15.50	32.21	41.50	9.40	17.30
4	63.50	93.50	195.50	17.55	44.86	44.00	9.60	15.95
5	62.50	92.00	165.00	12.30	34.60	43.00	10.25	16.90
6	63.50	93.00	194.00	17.55	25.29	43.00	9.90	18.55
7	63.50	93.50	202.50	14.35	37.15	41.00	9.55	17.10
8	62.00	93.50	200.50	10.45	37.56	41.00	9.70	16.15
9	64.00	94.50	160.00	15.20	35.19	43.00	9.60	17.35
10	64.00	94.50	190.00	15.15	39.98	43.50	9.15	18.35
11	61.50	91.00	155.50	14.90	27.89	41.00	10.5	15.05
12	61.00	93.50	183.00	14.15	45.04	42.50	8.95	16.40
13	61.00	91.50	187.00	13.45	34.20	42.00	9.15	16.35
14	59.00	94.00	172.50	12.10	30.17	43.50	11.4	13.95
15	59.50	94.00	184.00	14.50	37.88	43.00	8.95	16.10
16	62.00	92.50	182.50	14.70	31.70	42.50	8.95	17.55
17	63.50	91.50	142.50	13.55	23.58	45.50	10.50	12.27
Mean	**62.47**	**93.05**	**180.41**	**14.36**	**34.56**	**42.64**	**9.61**	**16.30**
S.E ±	**0.86**	**0.66**	**10.70**	**1.25**	**3.96**	**0.75**	**0.33**	**1.14**
C.D at 5%	**2.57**	**1.98**	**32.09**	**3.76**	**11.89**	**2.25**	**1.00**	**3.42**
SCG-62 : Control								
1	64.50	92.00	165.00	17.55	89.30	42.00	6.00	33.65
2	63.50	92.50	158.00	15.90	78.76	41.00	6.05	26.10
3	61.50	93.00	161.50	15.30	95.47	39.50	6.35	29.60
4	65.00	94.00	157.50	16.60	62.75	40.50	6.60	18.80
5	63.50	95.00	162.50	16.45	95.47	39.50	6.35	29.60
6	65.00	94.50	166.50	17.55	89.30	43.00	6.00	30.40
7	63.00	93.00	161.00	16.40	85.11	41.50	5.85	27.05
8	64.00	95.00	158.00	17.20	56.11	40.50	6.85	21.80
9	63.50	92.50	160.50	18.25	82.95	41.50	6.20	29.45
10	63.50	93.50	161.50	14.95	82.35	39.50	6.40	28.00
11	63.50	95.00	157.50	17.00	91.89	42.50	6.00	27.70
12	65.00	95.00	164.50	16.15	55.60	41.00	6.60	20.90
Mean	**63.79**	**93.75**	**161.17**	**16.60**	**80.42**	**41.00**	**6.27**	**26.92**
S.E ±	**0.45**	**0.65**	**1.81**	**0.53**	**6.44**	**0.69**	**0.17**	**2.20**
C.D at 5%	**1.40**	**2.03**	**5.65**	**1.65**	**20.04**	**2.15**	**0.54**	**6.88**

Continued…

Appendix II: Mean performance among mutant plants for yield and yield contributing characters in M_2 generation of confectionary sunflower.

Mutant Plants	Days to 50% Flowering	Days to maturity	Plant height (cm)	Head diameter (cm)	Seed filling (%)	Hull content (%)	100 grain weight (gm)	Seed yield per plant (gm)
SCG-62 : 100 ppm								
1	62.50	92.00	145.50	19.00	75.44	43.00	6.86	32.05
2	62.50	92.00	148.00	17.75	74.24	38.50	6.62	23.95
3	61.00	92.00	140.50	16.90	52.28	37.00	5.90	16.40
4	60.00	92.00	144.50	17.10	61.34	40.00	6.31	25.00
5	64.00	92.50	129.50	17.10	71.46	38.50	6.55	30.30
6	65.00	95.50	180.00	18.80	44.02	38.50	6.19	18.55
7	64.00	92.00	131.00	12.40	73.18	37.50	6.39	19.80
8	64.00	92.00	158.50	17.55	80.88	39.00	6.22	36.20
9	63.50	93.50	149.50	10.70	61.75	41.00	6.91	23.65
Mean	**62.94**	**92.61**	**147.44**	**16.36**	**66.06**	**39.22**	**6.44**	**25.10**
S.E ±	**0.66**	**0.58**	**5.76**	**1.48**	**4.70**	**0.93**	**0.16**	**3.50**
C.D at 5%	**2.16**	**1.90**	**18.79**	**4.84**	**15.33**	**3.03**	**0.51**	**11.42**
SCG-62 : 200 ppm								
1	61.00	93.00	176.00	15.70	71.22	39.00	6.37	23.15
2	62.00	93.00	167.00	17.45	47.07	38.50	6.48	20.45
3	63.00	93.00	160.50	18.90	60.91	41.00	6.24	25.90
4	62.50	93.00	142.00	15.00	82.58	42.50	6.48	28.05
5	66.50	94.50	138.50	13.20	71.70	40.00	5.80	22.55
6	61.50	93.00	152.50	14.55	72.03	38.50	6.57	12.55
Mean	**62.75**	**93.25**	**156.08**	**15.8**	**67.58**	**39.91**	**6.32**	**22.10**
S.E ±	**0.73**	**0.20**	**5.91**	**0.87**	**3.82**	**0.58**	**0.112**	**2.24**
C.D at 5%	**2.67**	**0.74**	**21.49**	**3.15**	**13.87**	**2.12**	**0.40**	**8.16**
SCG-62 : 300 ppm								
1	64.00	92.50	182.50	15.50	67.20	44.00	6.32	24.30
2	66.00	94.50	195.50	15.45	66.69	42.00	6.15	21.15
3	64.50	95.50	161.00	14.15	75.62	40.50	5.89	22.05
4	62.50	96.00	178.50	18.55	47.86	43.00	6.32	23.95
5	62.50	92.50	120.00	12.20	94.10	40.50	5.86	24.55
6	61.00	90.00	160.50	7.70	62.95	43.50	6.42	12.80
Mean	**63.41**	**93.5**	**166.33**	**13.92**	**69.07**	**42.25**	**6.16**	**21.46**
S.E ±	**0.73**	**0.75**	**11.72**	**1.63**	**6.52**	**0.58**	**0.10**	**1.68**
C.D at 5%	**2.67**	**2.74**	**42.59**	**5.95**	**23.69**	**2.12**	**0.35**	**6.11**

Continued…

Appendix III: Mean performance between treatments for yield and yield contributing characters in M_2 generation of confectionary sunflower.

Sr. No.	Name of genotype	Treatments/ Concentration (ppm)	Days to 50% Flowering	Days to maturity	Plant height (cm)	Head diameter (cm)	Seed filling (%)	Hull content (%)	100 grain weight (gm)	Oil content (%)	Sugar content (%)	Seed yield per plant (gm)
1	EC-625693	**Control**	68.37	91.58	150.94	15.72	60.24	43.32	7.82	25.13	1.43	26.24
2		**100 ppm**	62.10	88.63	146.18	18.88	66.86	44.10	8.08	31.02	1.49	27.79
3		**200 ppm**	62.79	89.00	149.58	16.79	60.88	45.00	8.17	28.03	1.51	23.30
4		**300 ppm**	65.17	91.06	162.82	16.54	46.05	40.15	9.55	25.97	1.40	22.815
5	EC-318761	**Control**	63.96	94.16	180.04	16.56	68.85	44.58	9.66	30.88	1.44	24.83
6		**100 ppm**	62.11	91.94	167.66	18.66	40.36	42.44	9.75	28.46	1.86	25.34
7		**200 ppm**	63.27	91.68	181.31	15.57	38.74	42.09	8.79	29.48	1.81	19.24
8		**300 ppm**	62.47	93.05	180.41	14.36	34.56	42.64	9.61	27.41	1.55	16.30
9	SCG-62	**Control**	63.79	93.75	161.17	16.60	80.42	41.00	6.27	31.11	1.71	26.92
10		**100 ppm**	62.94	92.61	147.44	16.36	66.06	39.22	6.44	32.04	1.82	25.10
11		**200 ppm**	62.75	93.25	156.08	15.80	67.58	39.91	6.32	31.95	1.84	22.10
12		**300 ppm**	63.41	93.5	166.33	13.92	69.07	42.25	6.16	30.23	1.96	21.46
	Mean		**63.60**	**92.02**	**162.50**	**16.31**	**58.30**	**42.23**	**8.05**	**29.31**	**1.65**	**23.45**
	S.E. ±		**0.46**	**0.27**	**2.91**	**0.40**	**1.80**	**0.37**	**0.17**	**0.65**	**0.03**	**0.70**
	C.D. at 5 %		**1.45**	**0.83**	**9.05**	**1.23**	**5.61**	**1.15**	**0.53**	**2.04**	**0.10**	**2.18**
	C.V. (%)		**1.03**	**0.41**	**2.53**	**3.44**	**4.57**	**1.23**	**2.97**	**3.16**	**2.86**	**4.23**

CURRICULUM VITAE

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1. Bachelor of Science **(B.Sc. Agri.)** with distinction (90.01 %) in 2016 from Faculty of Agriculture, Annamalai University, Chidamabaram, Tamilnadu India.
2. Higher Secondary School Certificate Examination (**H.S.C.)** with distinction (91.1 %) from Sri Chaitanya Junior College, Vijayawada, A.P in 2012.
3. Secondary School Certificate Examination (**S.S.C**) in first class (82.5 %) from Sri Sri Wisdom Model School, Piduguralla, Guntur District, A.P in 2010.

OTHER INFORMATION:

1. Post Graduate Diploma in Agricultural Marketing Management (PGAMM-Distance mode) in 2016.
2. Also having Experience of Poultry Production under experiential learning in 8th semester of Under Graduation.
3. I had worked as NSS volunteer during 2012-13.